V.

LECTURES AND COLLECTIONS

Made by

ROBERT HOOKE, Secretary of the *Royal Society*.

COMETA.

CONTAINING

- Observations of the Comet in *April*, 1677.
- Fragments of several Lectures about those of 1664. and 1665.
- Sir *Chr. Wren*'s Hypothesis and Geometrical Problem about those Comets,
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- The Author's Discourse and Description of Microscopes, improved for discerning the nature and texture of Bodies.
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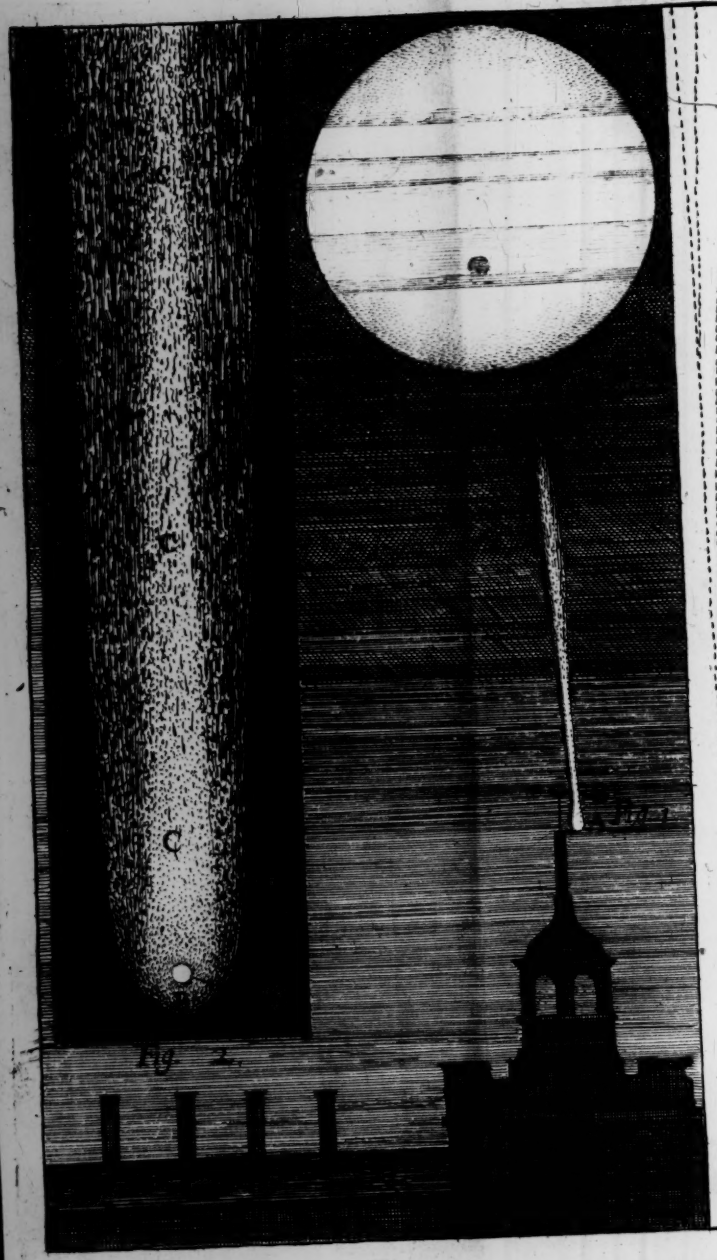
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Fig. 2.

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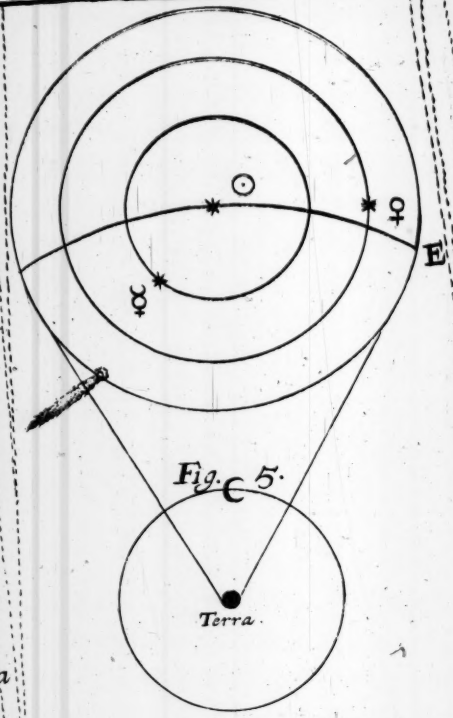
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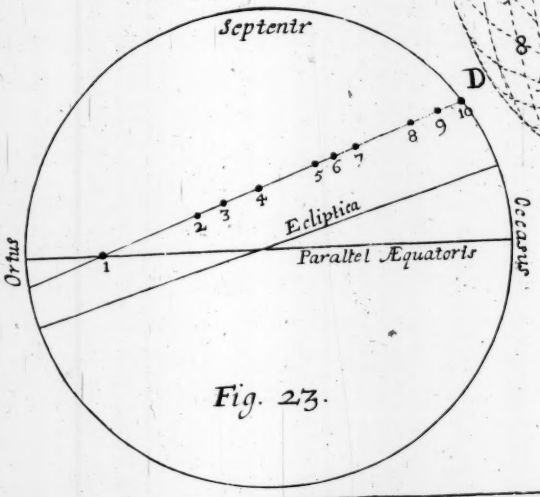
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Fig. 23.

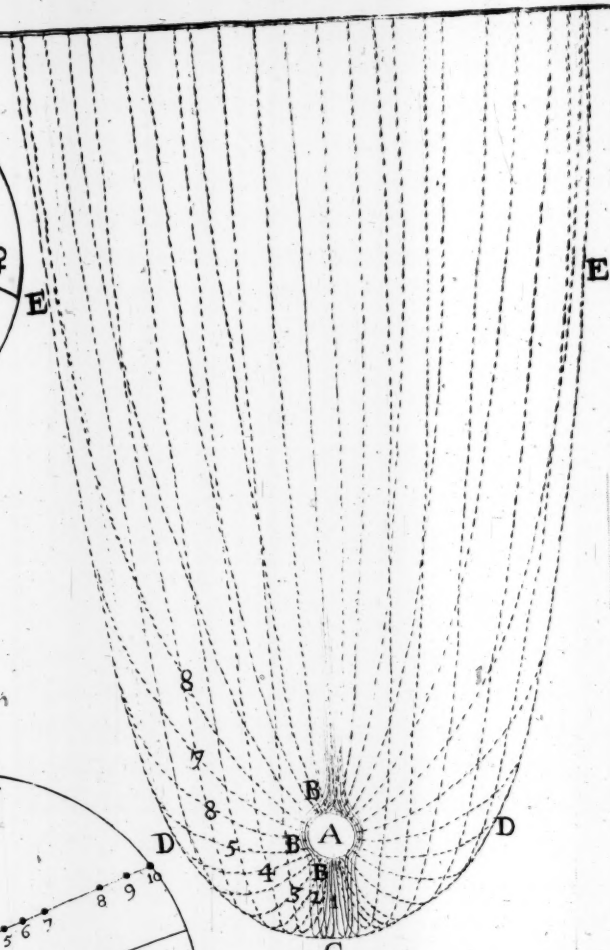
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Fig. 22.

Tab. I.

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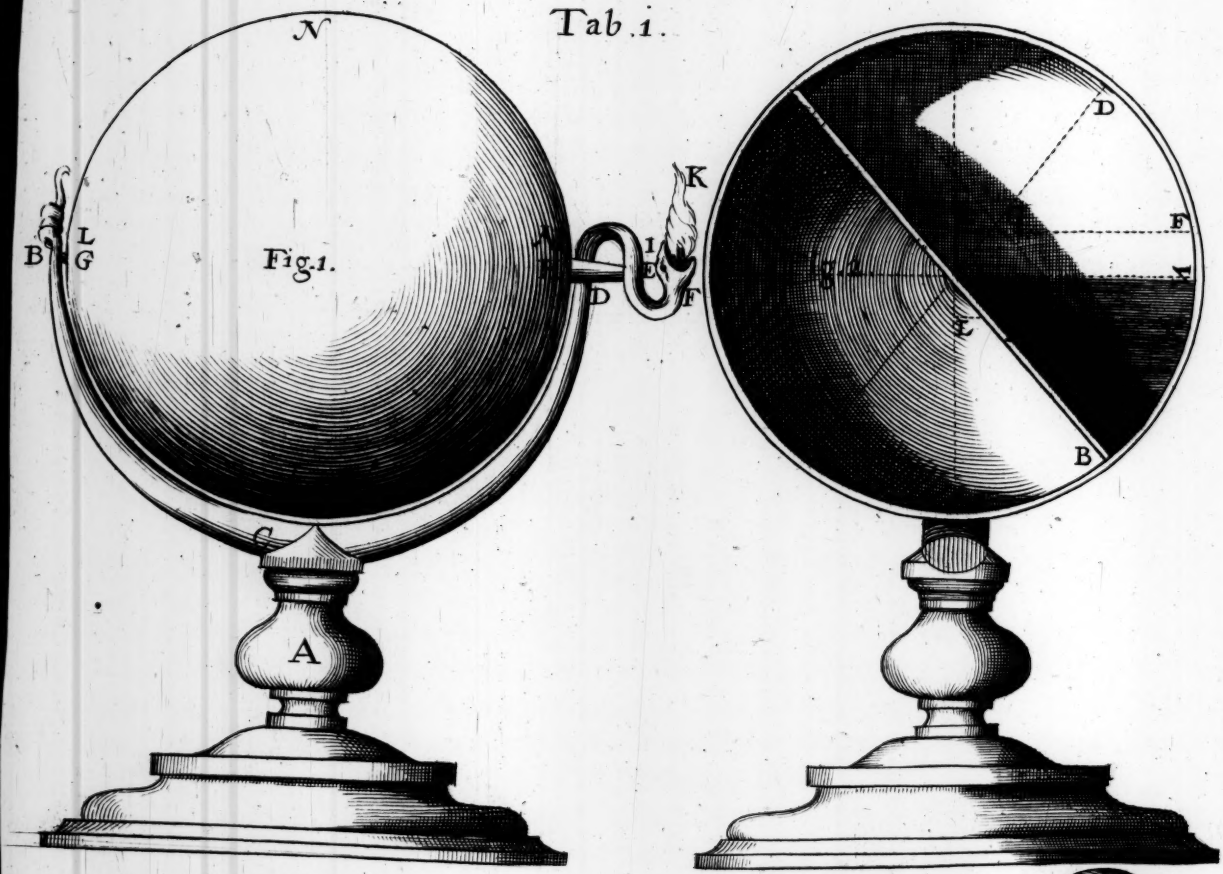

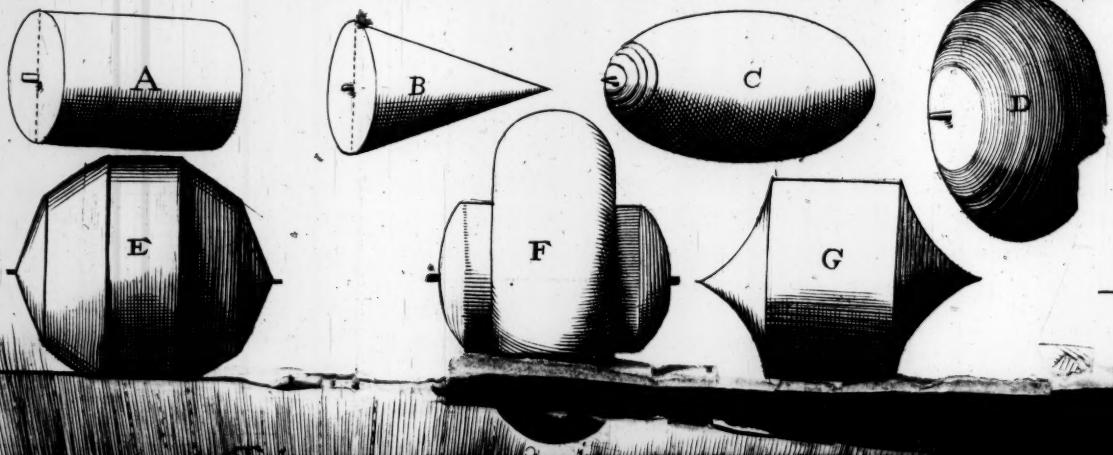

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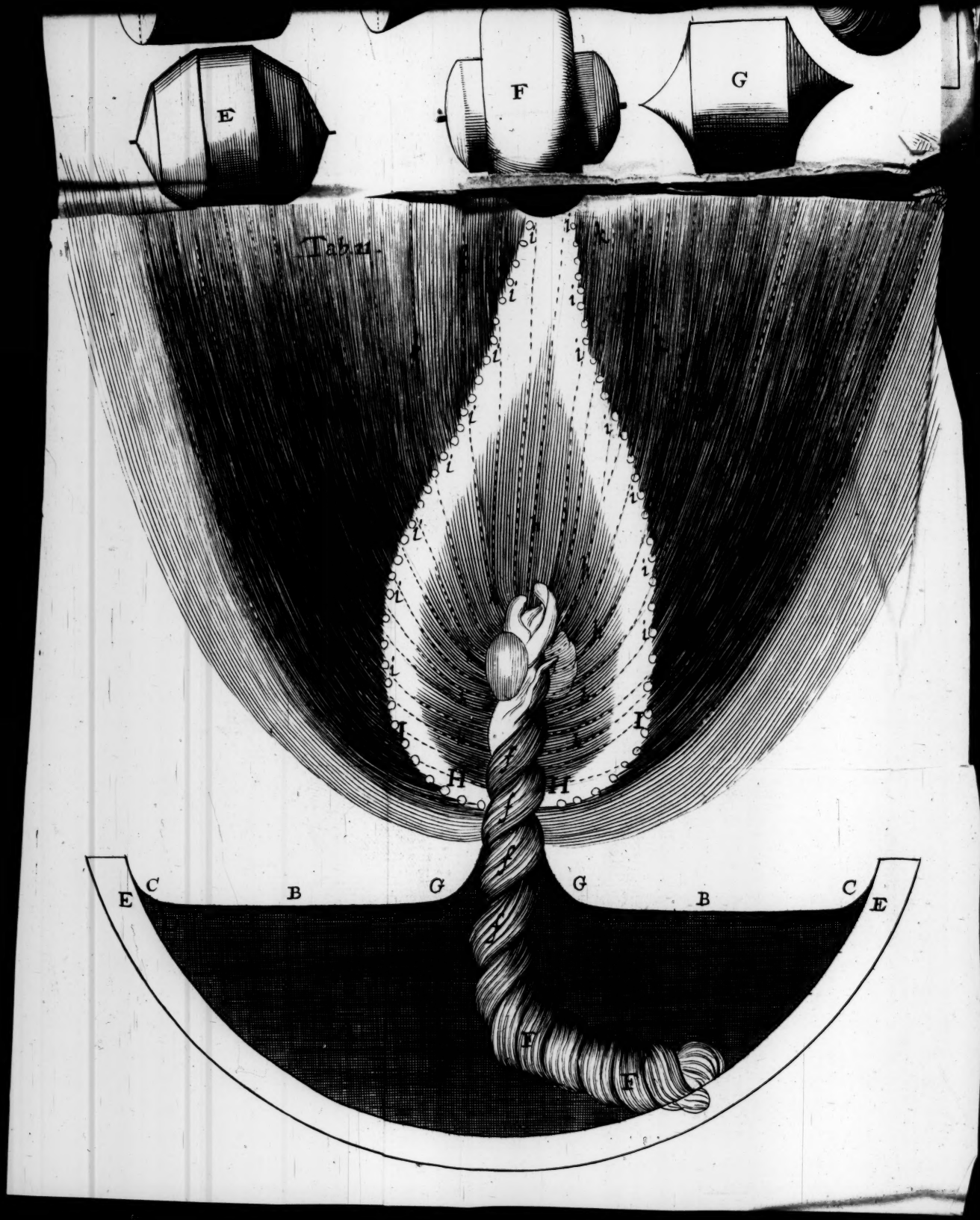
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Tab. III

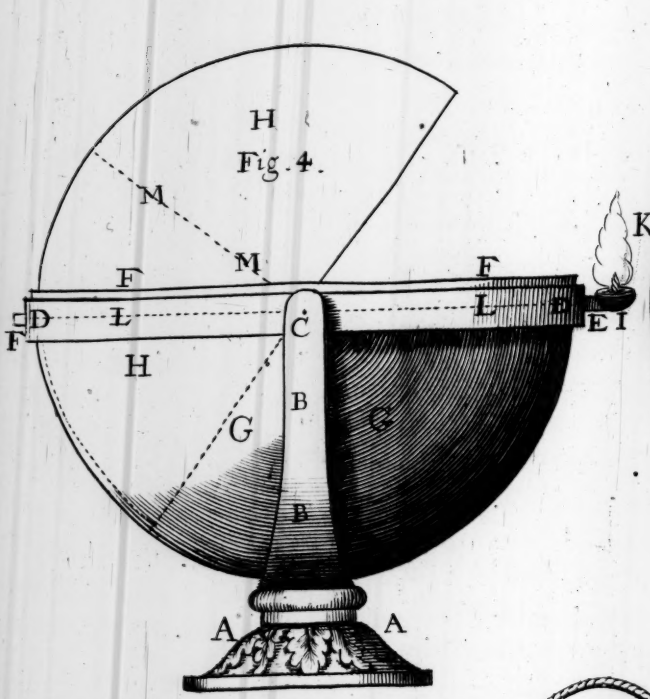

Fig. 4.

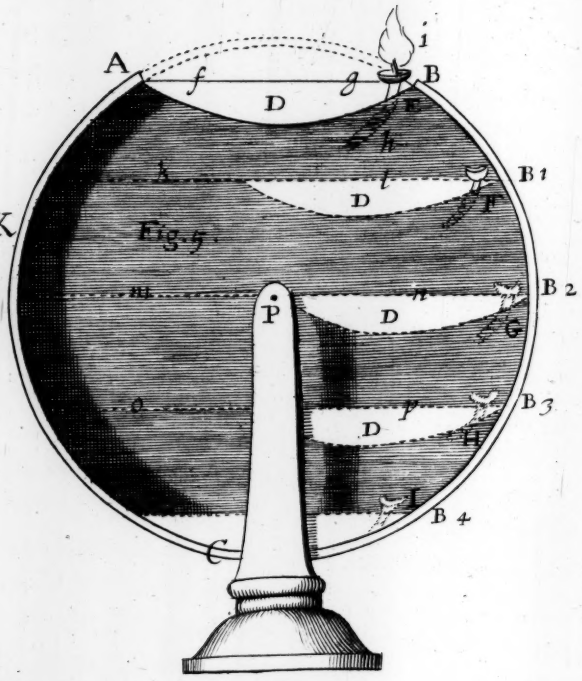

Fig. 5.

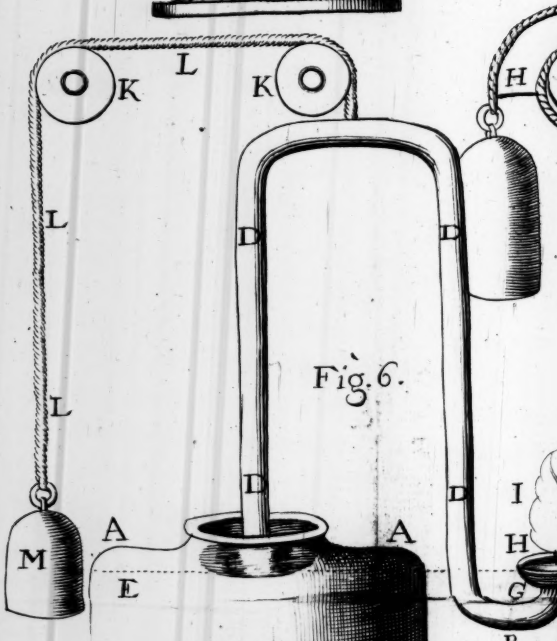

Fig. 6.

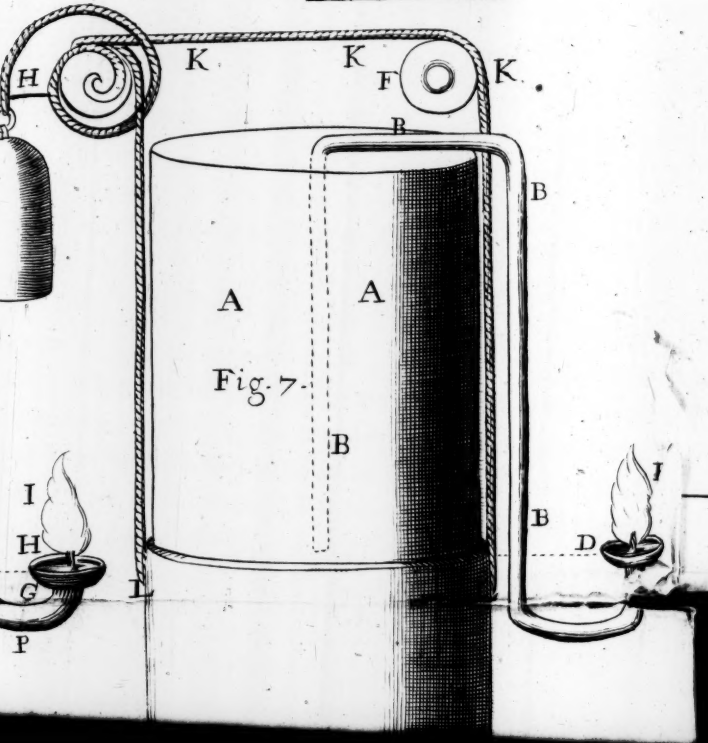

Fig. 7.

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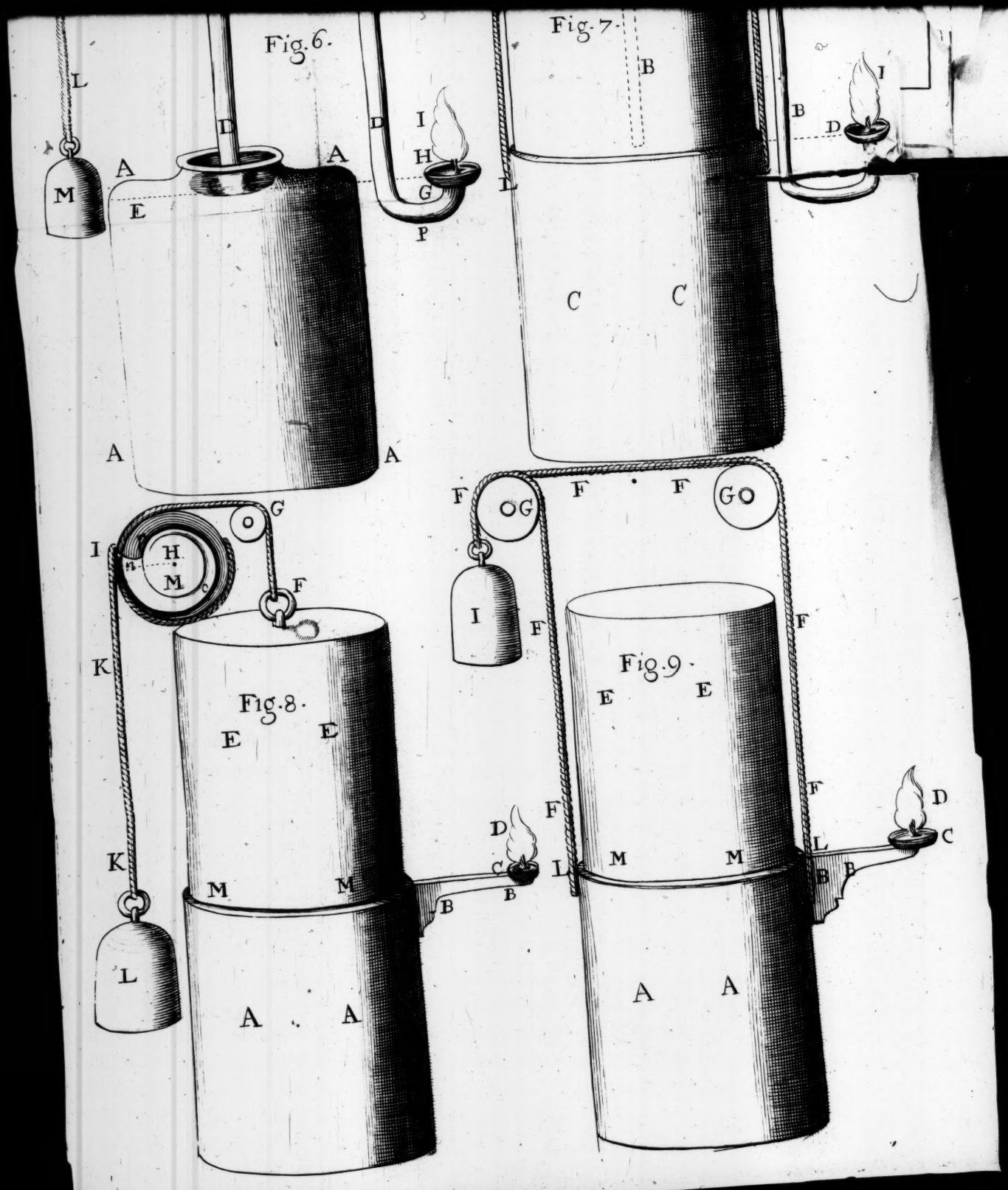
Fig. 6.
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Fig. 8.
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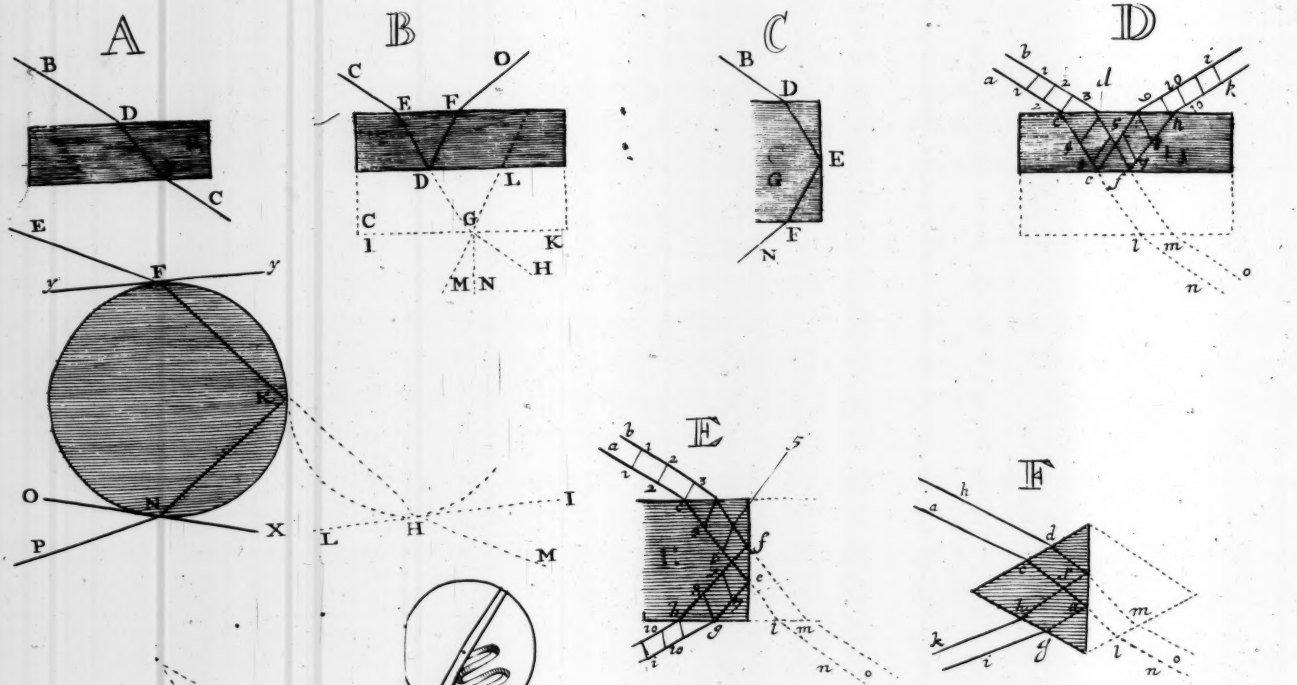
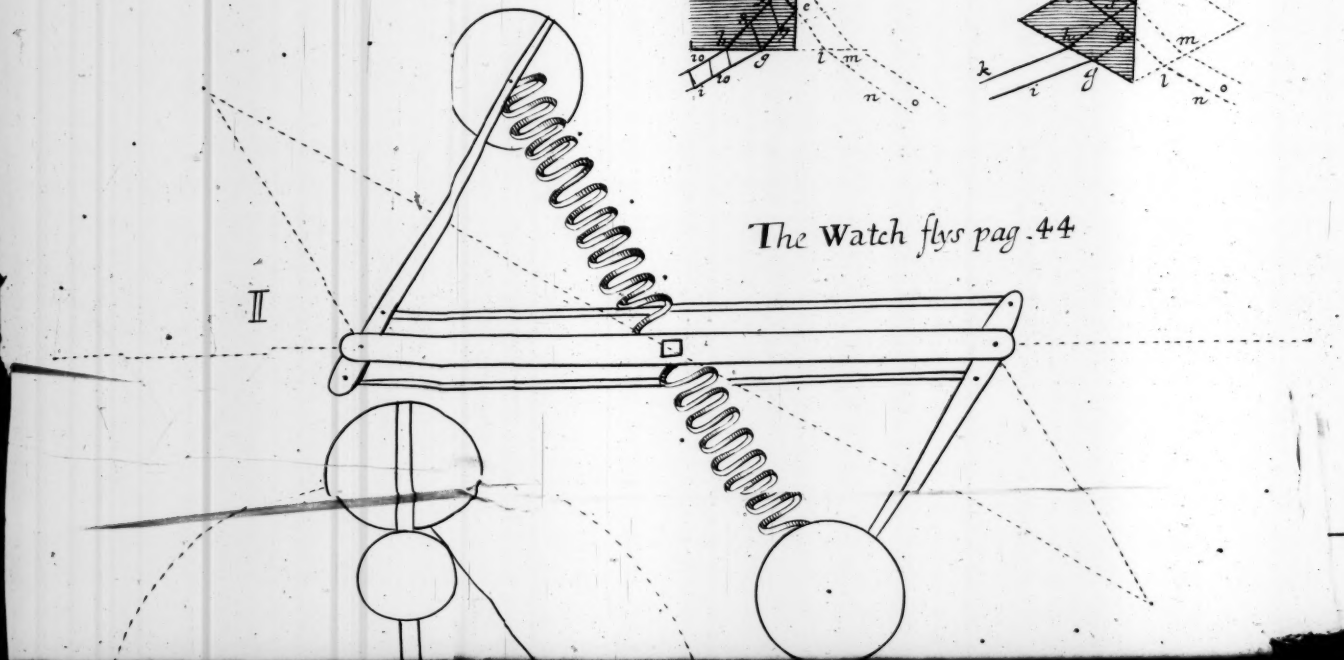
Tab. IIII.





The Watch flys pag. 44

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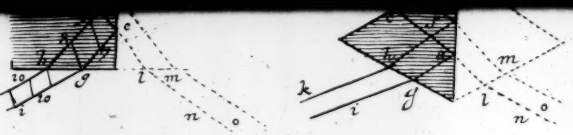
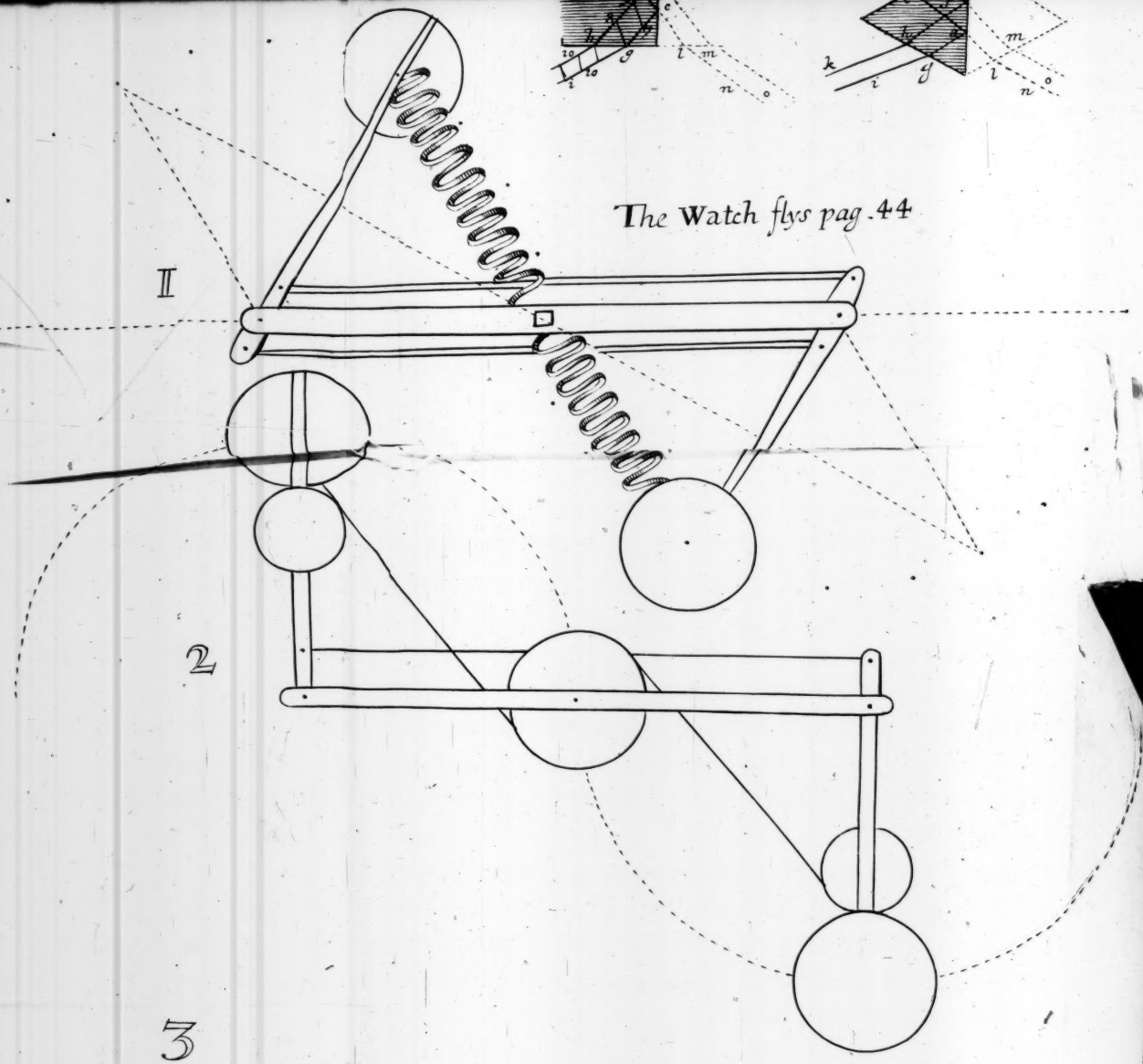


The Watch flys pag. 44

II



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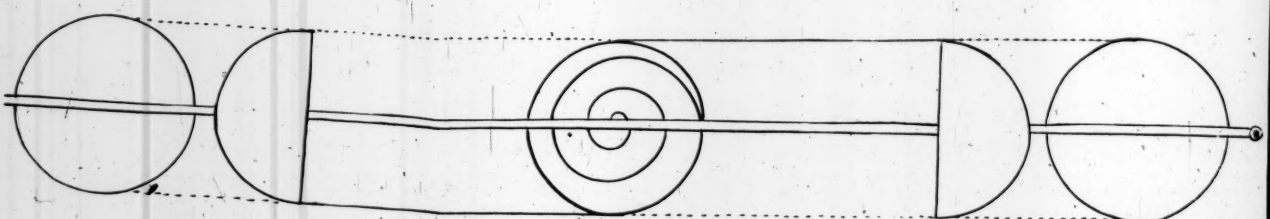

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BIBLIOTECA BOLLANA

V.

VIRO PERILLUSTRI

Dno JOSEPHO WILLIAMSON

EQUITI AURATO,

Sereniſſimo CAROLO IIo.

Mag. Britan. Fran. & Hibern.

REGI,

A Conſiliis Secretioribus, et a Secretis Status,

Nec non

SOCIETATIS REGALIS

LONDINENSIS,

Ad Scientiam Naturalem promovendam

PRÆSIDI

DIGNISSIMO.

NEC *potui, nec debui,* Nobiliſſime Vir, *cujuſquam aliûs nomen his Chartis inſcribere, præter* Tuum. *Sub* Te *natæ,* Tibi *vitam debent*; Ti-

bi *quoque debebunt quod lucem aſpiciant. Egregius ille* Tuus *animus ad inſtaurandam Philoſophiam arteſque adeo omnes utiles, mihi homini, alioquin ſubtimido, audaciam hujus dedicationis fecit. Ego quæ nunc potui, profero, magis ad Gratulationem oſtendendam, quàm Eruditionem. Spero autem, quemadmoduni ſub* Tuo PRÆSIDIO *majora indies Augmenta Scientiarum in hâc gente fiunt, ita exorituros viros doctos, qui* Tibi *juſta præconia laudum perſolvant; quod ego præ tenuitate ne conari quidem audeo, quanquam cum primis ſim*

Dignitatis & Honoris Tui

Studioſiſſimus,

ROBERTUS HOOKE.

SYNO-

SYNOPSIS.

THE Comet ſeen *April* 21, 1677. between the Triangle and the Cloud of ♈, its tail not directly oppoſite to the ☉, its Magnitude, Brightneſs, Head, Nucleus, Blaze, (1.) Why ſometimes ſhorter, ſometimes longer; without ſenſible motion of parts. Explanation of the firſt figure, as ſeen by the eye. (2.) Of the ſecond Figure, as ſeen through a glaſs, of a parabolick termination, differing from the repreſentations of Mr. *Hevelius*. (3.) The Medulla, and Blaze with the manner of ſhortning and lengthening, explained by the third figure; not ſeen the 22d. but the 23d. The bigneſs of the Nucleus and Head through a Teleſcope, compared with the top of a Tower. (4.) The place it then appeared in. Why the motion was not more exactly obſerved. Its blaze ſtill not oppoſite to the Sun. The 24th. not ſeen, nor 25th. (5.) though the Sky clear by reaſon of the height of Vapors. How they do lengthen the *Crepuſculum*. Why Phyſical Remarks only were made. (6.) Publiſhed in order to underſtand Objections, and propound pertinent Queries. Some Obſervations, Notes, Queries, *&c.* concerning the Comets in 1664. and 1665. here. Collected out of ſeveral ſcattered Papers and Lectures of them formerly read here imperfect. Queries of its ſubſtance, magnitude, denſity, mutability, diſſolution, fluidity, gravity, light, figure, motion bended or ſtraight, (7.) with equal or unequal velocity, in the Atmoſphere or Æther, above or below the Moon. Whether it waſts, or laſts to return. The Star of a compacted light (8.) varied poſſibly from poſition, partly from real change, Tail tranſparent, Body ſuppoſed more denſe, ſide toward the Sun evenly defin'd, Encompaſſed with a fluid yielding to motion, but diſſolving its parts. Its light from its ſelf. (9.) Its Nucleus ſuppoſed denſe poſſibly as the middle part of the Earth, of which ſome conjectures. Diſſolved by the Æther as in our Atmoſphere. (10.) Argument for the looſeneſs of the central parts of the Earth from the variation of magnetical direction. (11.) The Nucleus of Comets poſſibly the ſame. Internal motion may weaken gravitation. Parts ſeparated may be agitated by the gravitation of the ☉. Tail made not ſo much by the particles receding as the Stars approaching the Sun. (12.) How the Comet may firſt loſe its Orb in the Univerſe, and paſſing through the

ſpheres of Activity of ſeveral central bodies is deflected and attracted by them, and the Blaze raiſed to a prodigious length. (13.) The bodies being attracted by ſome gravity, Blaze expelled by levity, explained by ſmoke, and ſteams. Somewhat for poſitive levity. (14.) A digreſſion concerning the method of ſpeculating the great and firſt principles of the Univerſe. The *Coma* and Blaze like ſmoke or flames. (15.) Shining particles a ſhining point, not a line of light. Conſiderations and Experiments about the ways light is augmented by, as by ſwift motion, adjacent dark *medium*, Flame explained. Why the Particles coaleſce into a ſtream. (16.) Enquiry about the magnitude and place of Comets. Many ſuppoſed them ſublunary. *Tycho* and *Kepler* proved them cœleſtial. How far we may rely upon Obſervations for Parallax. Parallax and its effects deſcribed. (18.) *Tycho* ſuppoſed the Comet of 1577. to move about the Sun. *Kepler* that of 1607. to move in a ſtraight line; that of 1664. had no ſenſible Parallax by what means it was found. (19.) Refraction in this way varies little. Theory of Comets defective as to Parallax hitherto. Parallax not to be enquired from the Obſervations of ſeveral men. Errors creep in from the Preſs and the Graver, as in *P. Gottignies* Plates. (20.) Nothing to be concluded from Obſervations made by perſons in differing places for want of accurate Inſtruments, and Obſervations. (21.) Even the beſt as *Hevelius*, *Gottignies*, *Petit*, or *Auzout* err. Some reaſon for this aſſertion. Moſt of the reſt altogether inſignificant. (22.) Want of Obſervers, Inſtruments, and Tables the cauſe. How theſe wants are to be ſupplied. What the world expects from Mr. *Hevelius*. (23.) And of how great uſe his Tables and Projections made by them will be. Parallax from diurnal motion failing. (24.) Other Parallaxes ariſing from other hypotheſes of the proper motions either of the Earth, or Comet, or both together conſidered ariſe to a certainty. (25.) Others depending upon other ſuppoſitions define nothing of the magnitude or diſtance of Comets. The inconvenience of *Tycho*'s, and alſo of *Kepler*'s Hypotheſes explained. A third way I have taken. What conſequences follow from it, (26.) As that it moves in a Circle that comes within the Earth Orb in ☊, and without ♈ Orb in ♒, a ſextant in 130 days, *&c.* This not relied on, becauſe there may be other hypotheſes to ſolve the phænomena; as that the Earth is unmoved, and the Comet moved in a Circle, whoſe convex ſide is toward the Earth. (27.) This hypotheſis explained by the ſixth figure. (28.) The diſtance and bigneſs of the Circle of the Comet undeterminable this way without a diurnal parallax, ſince the appearances may be ſolved by Circles of any bigneſs, proved by the eighth figure, (29.) Allowing inequality of motion, or

more

more compound curve lines, nothing can be determined. The circular Orb it ſeemed the moſt probable ſolves *Kepler*'s acceleration, according to the increaſe of a line of Tangents. (30.) A gravitation towards the Sun makes out the motion of the Comet, and Planets, and of the Blaze. The Blaze explained by experiment of ♂ diſſolved in oyl of Virt. (31.) This experiment and hypotheſis farther explained, and applied to explain the Blaze which is from thence bent, brighter on one ſide than the other, not direct from the Sun. (32.) Cometical body and motion as old as the world, yet waſting in the Æther; explained by fire. Diſſolution by *menſtruums*. (33.) Thence the proprieties of Comets conjectured, and the ſum of the foregoing diſcourſe repeated, being the end of a Lecture. Recourſe to *Tycho Brahe*'s Obſervation (34.) for making out the Comets Orb. His ſuppoſing its motion unequal without reaſon a ſhift. Mr. *Horrox* his hypotheſes in the ninth figure a product of chance. (35.) A diſcourſe on it, and ſome objections againſt *Tycho*'s. (36.) *Kepler*'s hypotheſis examined by theſe Obſervations of *Tycho*'s, found the moſt likely, but with ſome alteration. Line of Trajection bent a little. Motion accelerated towards the Sun, retarded from it. (37.) The ſwifter and further off the Comet from the Sun, the leſs the bend, explained by the tenth figure. (38.) The way of enquiring parallax by Teleſcopes, (39.) further explained. A ſecond way by two Obſervers in diſtant places propounded. The third way of Sir *Chr. Wren* his Majeſties Surveyor-General, (40.) Set down and demonſtrated by a Geometrical Problem. (41.) How exactly all thoſe Obſervations he had were made out by it, together with his own Schemes; both which I had in the beginning of *Feb.* 166$\frac{4}{5}$. (42.) Some other Papers about Comets added, being reflections on Mr. *Deſcartes* and *Kepler*'s hypotheſes, from particular tracings of the Comets of 1664. and 1665. A Scheme of the later Obſervations of that of 1664. added, and ſome reflections, being all the papers could be found about thoſe Comets. (43, 44.) Animadverſions on this of *April* laſt. Why the former conjectures were adhered to concerning the light of Comets. (45.) Several ſorts of ſhining bodies enumerated. (46) To which the light of the Comet ſeems to have moſt affinity, and how produced. (47.) Further deſcribed and explained. (48.) The reaſon of its parabolick figure demonſtrated from the proprieties of motion from or toward a gravitating body, as the Sun. (49.) Concerning the waſting and laſting of the Cometical body. The bigneſs and nature of the Particles that compoſe the Blaze. (50.) Some difficulties in this ſuppoſition concerning the action of the Æther in levitation and aſcent, diſſolution, ſhining, *&c.* cleared and explained by Experiments. (51, 52, 53.) But would have been further examined by Ob-

Obſervation if there had been opportunity. (54.) That theſe aſſertions about the light of Comets may not ſeem too paradoxical, ſome further Conſiderations and Obſervations about light are added, and ſome new ways propounded. (55, 56.) Mr. *Boyle*'s Memorial concerning a Phoſphoros, written for his own uſe, inſerted; in which he firſt names the Author of it, and deſcribes his *Apparatus*. (57, 58.) Then the obſervables. 1. Two ſpoonfuls of matter enlighten a large glaſs ſphere. 2. A little enlightens a large Cylinder. 3. Liquor ſhaken had a ſmoke and flaſht. 4. A dry ſubſtance affirmed to have continued ſhining 2 years, flaſhed. (59.) 5. Some duſt of this on a Carpet twinckled like Stars. Writing on paper with it ſhin'd, and ſmelt of Sulphur and Onions. (60.) 7. The hand on which it was rubbed, ſhin'd, but felt no heat. (61.) It fired Gun-powder firſt warm'd. (62.) And white paper held over coals. Other tryals propounded, but refuſed. (63.) Some Experiments made on the Phoſphoros *Baldwini in vacuo*, and in the open air. (64.) Preſerved in *Vacuo*, but deſtroyed in Air. (65, 66.) Monſieur *Gallet*'s Letter to Monſieur *Caſſini*, acquainting him with his *Apparatus* for obſerving ☿ in ☉. (67, 68.) His Obſervation of four ſpots in ☉. (69.) The particulars obſerved. (70. 71, 72.) Monſieur *Caſſini*'s Reflections on theſe Obſervations. (73, 74.) Mr. *Hally*'s Letter to Sir *Jonas Moore*, containing an account of his Obſervations of ☿ *ſub ſole*, three Southern Stars. The two *Nubeculæ*, *&c.* (75, 76, 77.) Mr. *Caſſini*'s farther diſcoveries about the diurnal motion, and ſeveral new appearances in ♅. (78, 79, 80.)

A ſecond Diſcourſe called Microſcopium, or ſome new diſcoveries with Microſcopes, in a Letter of Mr. *Leeuwinhoeck*. (81. 82.) A confirmation of ſome of them by Obſervations here. (83.) Mr. *Leeuwinhoeck*'s ſecond Letter, containing Obſervations of the Globules of Blood, Milk, Flegm, Gums firſt diſſolved, then precipitated out of the Spirit of Wine; Eels a thouſand times thinner than a hair. (84, 85, 86, 87, 88, 89.) The ways how theſe diſcoveries were made here. 1. By holding the liquor in ſmall pipes, how fill'd, how made. The Lamp, Pipe, Oyl, Manner, Materials for making them deſcribed. (89, 90.) Muſcovy-glaſs uſed inſtead of theſe Pipes, and how the Microſcope was fitted for this purpoſe. (91.) What light convenient. Surfaces of bodies not perfectly fluid apt to delude an Obſerver. (92.) Plates removing that deluding cauſe, and what farther uſe of them. (93.) How to find the figure and texture of Animal and Vegetable parts. Inſtance in a ligament of Beef. (94.) The figure of Muſcles hinted, and an inſtrument ſtretching them before the Glaſs deſcribed. (95.) A deſcription of the Microſcopes uſed, 1. Of the ſingle Microſcope, and its advantages and difficulties. (96.) another ſort more eaſie deſcribed, and the ways how to make and uſe it explained. (97.) Cauſes that vary the diſtance of objects from the Globule. The uſe of Selenites and Looking-glaſs-plates, for holding the liquor. A Microſcope of one ſingle refraction. (98.) The only inconvenience of them hinted, how prevented by double Microſcopes. Where theſe are made. (99.) The double Microſcope, and its parts, uſes, and advantages deſcribed. (100.) The benefit of a dark Room, and appropriated lights. And a digreſſion in anſwer to *P. Cherubines* Accuſation. (101.) Some Obſervations made with this Microſcope hinted. Animalcules in the ſteeping of other Grains beſides Pepper. Their ſmallneſs eſtimated, and compared to a Whale. Muſcular fabrick hinted. Milk, Blood, Fat, Sugar, Allum, *&c.* viewed. (102, 103.) Mr. *Young*'s Letter of one who trying to cure a Colick by leaden Pills, ſlipt one into his Lungs; grievous ſymptoms enſue. (105.) Helps of skilful Phyſicians in vain attempted, and particularly of Dr. *Mayow*, of ſuſpending with the head downward; though in the interim he married and had Children, yet it kill'd him. (106, 107.) His body diſſected, and remarkables taken notice of, and their cauſes explained by Mr. *Young*, (from 107. to 112.)

COME-

BIBLIOTHECA BODLEIANA

Tab: II.[a]

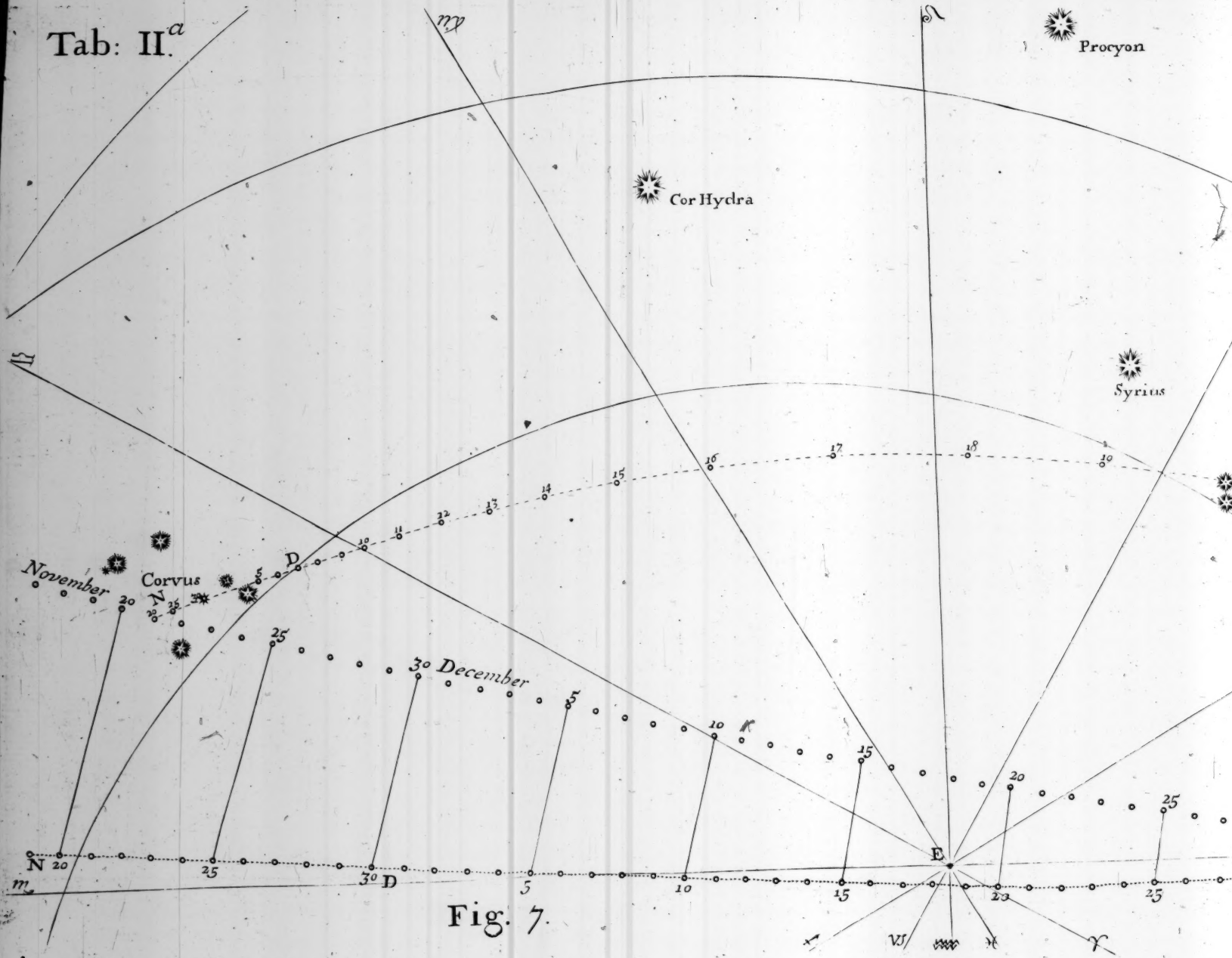

Fig. 7.

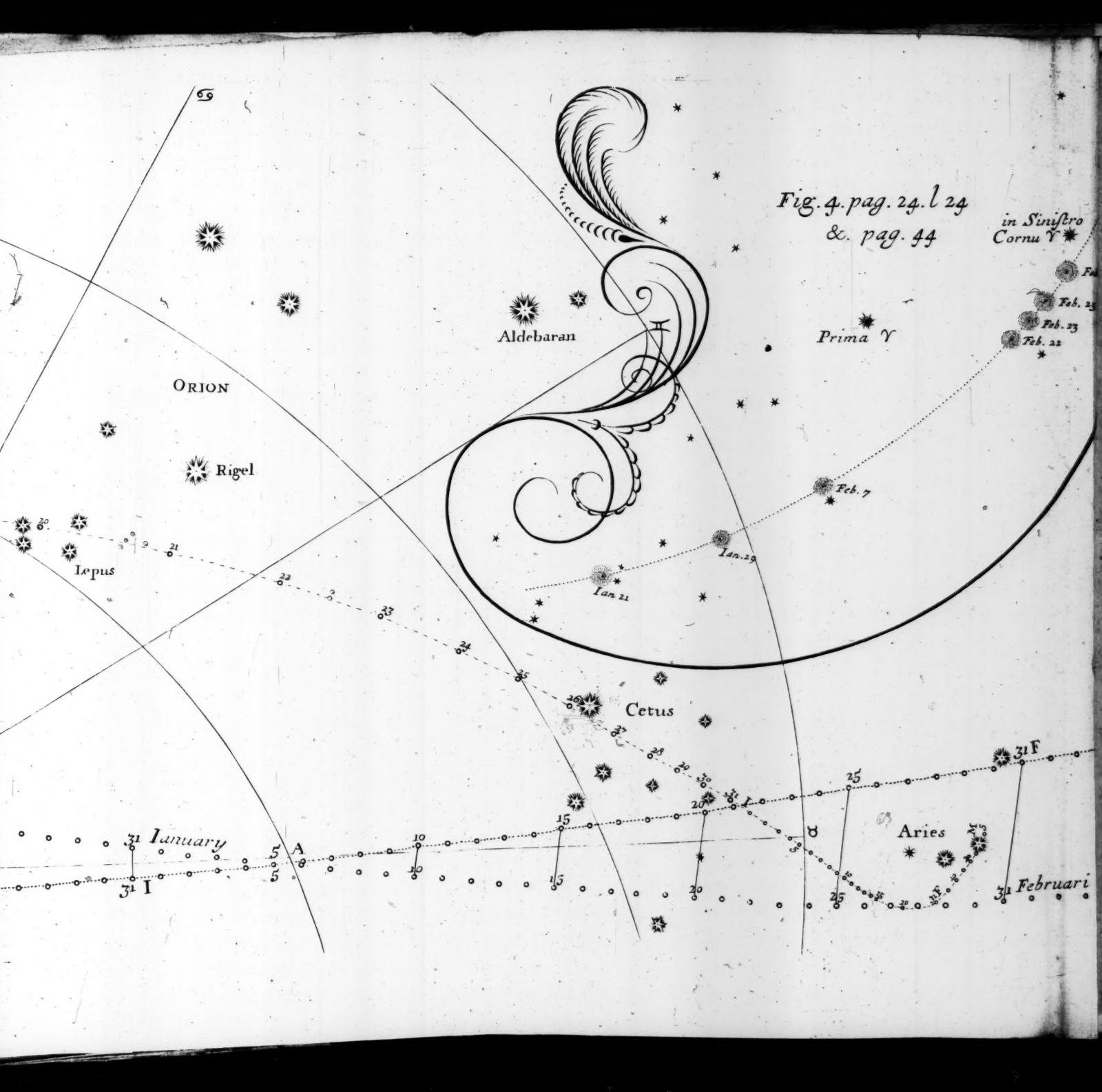
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Fig. 4. pag. 24. l 24
& pag. 44
in Sinistro
Cornu ♈
Aldebaran
Prima ♈
ORION
Rigel
Feb. 7
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Jan 21
Lepus
Cetus
Aries
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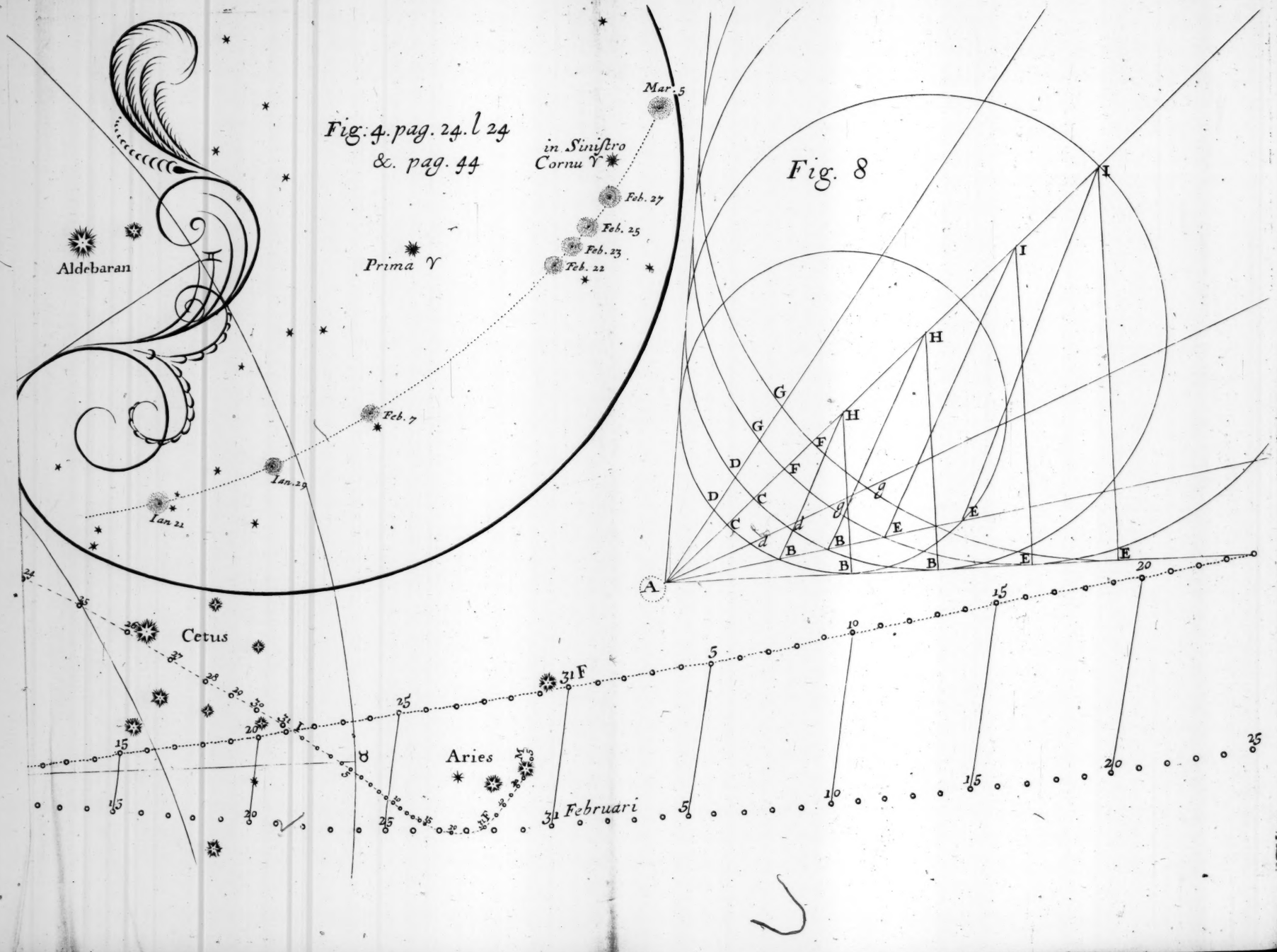
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Mar. 5
in Sinistro
Cornu ♈
Feb. 27
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Feb. 22
Prima ♈
Aldebaran
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Jan. 29
Jan. 21
Cetus
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31 Februari
Fig. 8
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COMETA,

OR,

Remarks about Comets.

ON *Saturday* morning, *April* 21. 1677. I first saw the Comet, of which I had been advertised the day before. It appeared in the Sign *Taurus*, between the base of the Triangle, and the unformed Stars in the Cloud of *Aries*, dignified by *P. Pardies*, with the figure of the Flower-de-luce. The head of it was in a right line, with the heart of *Cassiopea*, and *Alamak*, or the South foot of *Andromeda*. and as near as I could judge by my naked eye (having no Instrument or help by me) it was $\frac{1}{6}$ of the distance between the feet and the Girdle of *Andromeda*, distant from the said *Alamak* towards the South.

Its tail sometimes as the Air was clearer and darker, extended about three quarters of its distance from the aforesaid *Alamak*, and pointed directly at the Star in the nose of *Cassiopea* of the fourth Magnitude, and consequently the head of the Comet pointed not directly at the Sun (the Sun then being about the eleventh degree of *Taurus*) but rather towards the fourteenth degree of the same Sign. Its appearance was very small and slender, and as people commonly ghessed, about two yards long; and the head about the bigness of a Star of the first magnitude, but of a much fainter and duller light. Its blaze about three o'the clock seemed to rise straight upward

ward, before that about half an hour after two it leaned a little Eaſtwards, or towards the right hand, and after three, as it roſe higher, inclined towards the left ſide or Weſtwards. The head to the naked eye was brighter than the blaze, and ſeemed to be ſomewhat bigger than that part of it which immediately joyn'd to the head; but thoſe parts of it which were farther diſtant, were of a much greater breadth; ſpreading wider and wider, as they were more remote from the head, and in the ſame proportion alſo growing fainter and fainter in their light, eſpecially towards the outſides: but the middle parts or *medulla* appear'd much longer, and the brightneſs much greater, which made the whole blaze to ſeem to taper, or be pointed towards the top.

The length of the Blaze appeared ſometimes ſhorter, and ſometimes longer, by ſeveral viciſſitudes; and as the day-break, or dawning increaſed, ſo the Blaze ſhortened, and eſpecially towards the ſides near the top, and ſhortly after before the Sun roſe, diſappeared.

But notwithſtanding this ſhortning and lengthening of the Blaze, I could not perceive any kind of motion in the parts of it, ſuch as is obſervable in flame, ſmoke, or other ſteams riſing from a burning or hot body: but the ſame parts of the Blaze ſeemed to appear and diſappear in their proper places as if they had been fixed and a ſolid body.

The firſt Figure I have here annexed will with ſome ſhort explications, repreſent the appearance of it to the eye, more plainly than by a multitude of words, without it 'tis poſſible to expreſs.

A, repreſents the head of the Comet, the middle of which appeared brighter than any other part; about which was a hazy light ſomewhat like the ſhining of a Star through a thin cloud; the lower part of which was pretty round and defined. B, the neck of it, which ſeemed to the naked eye of leſs Diameter, and leſs bright than the head, but through a ſix-foot glaſs, as I

ſhall

ſhall mention by and by, it appeared bigger, though not ſo bright. The middle of this was very bright, and ſeemed to iſſue from the *Nucleus* or Star in the middle of the head. C, the bruſhy parts which were fainter and paler towards the ſides, eſpecially nearer the top, which made the whole ſeem to taper and reſemble the Figure here expreſt: Obſerving it with Teleſcopes (one of which was fifteen foot, and the other ſix foot long) I found the ſhape of it much like this, which I have repreſented in the ſecond Figure.

It had a pretty bright Star (if I may ſo call it) near the middle of the head, ſeeming much about the brightneſs of ♄ when near the Horizon, and was about 25 ſeconds in Diameter; as is repreſented by A, not perfectly defined, but hazy; the cloudy part or beard of the body encompaſſing it on all ſides; but that part of the *Coma* B, which was next towards the Sun, was the narroweſt: nor was this *Coma* well defined, but the outward parts of it were fainter and fainter. However they were regularly enough terminated to make the outwardmoſt bounds of it of a kind of Parabolical figure; the moſt bent part of which was towards the Sun, and moſt defined: And the bright Star of it was, as I have expreſſed it about four of its Diameters diſtant from the ſaid parabolical limb. The light parts of the ambient Cloud ſeemed to ſpread gradually towards that ſide of it, which was oppoſite to the Sun; but thoſe which were next the middle were the brighteſt: and always as they were farther and farther from the Star in the head, the fainter and paler they were.

I could not obſerve any repreſentations like thoſe which are given us by Mr. *Hevelius*, in his Cometography, neither in the Head, nor the Blaze, no more than I could in thoſe which appeared in the years 1664. and 1665. as may be eaſily taken notice of by comparing theſe which I have here delineated with thoſe.

The middle part of the Blaze CC, which aſcended from the Star in the middle, ſeemed the brighteſt, and

of this *medulla* or ſtem, thoſe parts were brighteſt which were neareſt ſituated to the ſaid Star. The ſides of it grew fainter and fainter, as they were farther from the head; and though they had brightneſs enough to make them appear in a dark and clear sky, yet the dawning quickly made them vaniſh, and diſappear, as did any hazineſs of the Sky: and according as the light increaſed, ſo was the Blaze diminiſhed, after the order of the tapering prickt lines expreſt in the third Figure by a a a, b b b, c c c, d d d, *&c.* and even in a clear and dark Sky, towards the farther end of the Blaze they often diſappeared for ſome ſhort ſpace of time, though the middle or ſtem continued; and ſo it cauſed the remaining appearance to reſemble the figure of a very ſlender birchen whisk or bruſh, much like that repreſented in the firſt figure.

The 22. from half an hour after two, till half an hour after three, the North-eaſt part of the Heavens to me was cloudy, and the Sky between the Clouds was hazy, and the dawning ſtruck much higher than the day before, ſo that I could not find it.

The 23. with ſeveral friends I obſerved it again, the Sky being clear, and confirmed my ſelf in all my former obſervations, taking again diligent notice of all circumſtances remarkable, both with my naked eye, and with Perſpective-glaſſes. And I had this morning a very notable obſervation in order to meaſure the bigneſs of the Star and its *Coma* which encompaſſed it, by comparing it with ſomewhat fixt: for ſome few minutes before three of the Clock the head of it paſt juſt behind the type or top-poſt of a tower not far diſtant, and was quite eclipſed by it; and as ſoon as it appeared to have paſt it, ſeeming yet contiguous, I obſerved it with my ſix foot Teleſcope, and found the Coma or whole head to appear full as big as the ſaid type or timber poſt, and the *Nucleus* or Star in the middle of it, to be very near of the ſame bigneſs of the iron ſpindle, upon which the weather-cock was fixt. Whence upon examining the

bigneſs

bigneſs of the ſaid parts, ſince by an accurate Inſtrument I judge the head or Coma was about 4 ½ minutes in Diameter, and the *Nucleus* or Star about 25 ſeconds. I took notice this morning that it had much altered the poſition in the Heavens, which it had upon Saturday morning, and that the Blaze of it was very much deflected out of the line it appeared in the laſt time. And with a ſmall croſsſtaff, taking the diſtance of it from *Alamak*, and from *Genib*, in the left ſide of *Perſeus*. I judged it to be in the mid-way between the Flower-deluce aforeſaid, and *Algol*, or the head of *Meduſa*, that is, about 14 degrees of ♉, and 17 degrees of Northern Latitude: ſo that I judged its motion almoſt Eaſt, but a little deflecting South. I was not much ſolicitous of making obſervations of its true place, as not deſigning my preſent enquiry to be for what kind of motion it had, conceiving its motion to be towards the Sun, and ſo of very little duration: and expecting to hear an account of that from other places, and perſons that were better furniſhed with Inſtruments and conveniences for obſervations of that kind than I was then.

The Blaze extended it ſelf in a right line towards the Star in the right thigh of *Caſſiopea*, being a Star of the third magnitude. Its length at firſt was about 7 or 8 degrees, and did ſometimes ſeem longer, ſometimes ſhorter, as I noted before, without ſeeming to have any other motion in it but the Diurnal motion, the ſame with the fixt Stars on Earth. Whence I collected, that the head of it pointed towards the ſeventeenth degree of *Taurus* in the Ecliptick, though the Sun at that time was about the thirteenth degree of the ſame Sign.

The 24. with ſeveral others, I attended the appearance of it, but the Sky in that part of the Heavens was over-caſt with Clouds.

The 25. I expected to have a farther Obſervation of it from half an hour after two, till a quarter after four; but notwithſtanding the South-eaſterly wind, and the clarifying quality of the air, which before half an hour

after three had partly carried off, and partly diſſolved the black thick Clouds (with which the North-eaſt parts of this Horizon was over-caſt about three of the Clock) and left that part of the Heavens where the Comet ſhould have appeared clear, and without Clouds. Yet the air being very high and heavy, as the Barometer ſhewed, the upper parts of it were ſo filled with the dawning light of the morning, that neither the Blaze head or Star of the Comet appeared to me in the leaſt: nor had I any ſight of it ſince.

The like appearance of the great height of vapors in the air, when it is very heavy, I have often taken notice of, and have obſerved, that the twy-light and dawning between the night, and appearing of the Sun is very much altered thereby. And that a heavy air, when the vapors are raiſed high, will make the length of them much greater, and conſequently the night ſhorter. And a light air, on the contrary, ſhortning them, doth lengthen the night.

Theſe were the moſt remarkable circumſtances I took notice of in this Comet, being altogether Phyſical, and deſigned only for enquirng into the conſtitution of theſe wonderful bodies: the accounts and opinions we have hitherto had of them of that kind, being very unſatisfactory. Though other Obſervations, to wit, Mathematical, of the way, celerity, and magnitude of Comets have been proſecuted with very much care, and great skill; ſuch as thoſe of the noble *Tycho*, and the learned and diligent *Hevelius*, inſomuch that I could not expect to have better; yet as to Phyſical remarks, I wanted much information to be able to ſatisfie many difficulties that occurr'd to my thoughts, upon enquiry into the particular natures of them. I did therefore, as I deſigned, employ all the time I could get of obſerving this Comet, in taking notice of ſuch circumſtances as I judged would be pertinent to reſolve any of thoſe Queries I had formerly made, in order to find out the nature of Comets in general. And though the little opportuni-

tunity I now had, and the disadvantageous appearance of this last were very short of giving me that satisfaction in many particulars which I wish'd for, and expected at first, yet since they may possibly serve for hints to others that may hereafter have better oportunity than I, and that I might understand what material objections could be made by observers from preceding Comets, and that they might for the future more diligently take notice of what from these queries and hints may be judged significant to this design, such as they are I have here published as I had done formerly by my Lectures in *Gresham*-Colledge, those which I had made of those in 1664. and 1665.

Now before I come to make reflexions upon these remarks, I thought it might not be improper to add some few of those things concerning those two former Comets observed by me in the said years. I say, some few, because it would be needless to set down all, especially such of mine as do agree with others since published. I did therefore soon after I had seen the first Comet, to wit, *December* 23. 1664. propound to my self certain Queries necessary to be answered, in order to find out a true theory of them, and directed my Observations accordingly; and they were these.

Of what substance its body, beard, and blaze is? and next, of what magnitude each of those parts appear, and of what real magnitude they are?

Other Queries were concerning its density and rarity, its mutability or immutability; that is, whether it dissolved and wasted or not? whether it were fluid or solid? whether it participated of gravity or levity?

Whence it had its light, colour, *&c.*

What was the figure of the Star, Radiation, Blaze, *&c.*

Whether the Blaze were always opposite to the Sun, or deflected? whether straight or bended, *&c.*

What kind of motion it was carried with? whether in a straight or bended line? and if bended, whether in a circular or other curve, as elliptical or other compoun-

pounded line, whether the convex or concave ſide of that curve were turned towards the earth? Whether in any of thoſe lines it moved equal or unequal ſpaces in equal times?

Through what parts of the univerſe it moved, and how far diſtant it was at ſeveral times? Whether in the lower Regions near the Earth in the Atmoſphere, or near it, or in the Heavens, or fluid Æther, with which the ſpace of the Heavens is filled? Whether above or below the Moon, *&c.*

Whether it waſts, and is diſperſed and conſumed? or whether it laſts and endures for a longer time? If it laſts, Whether it ever appears again, being moved in a circle; or be carried clear away, and never appear again, being moved in a ſtraight or paraboloeidical line? Whether it be collected or generated when it firſt appears? and diſſipated or deſtroyed when it diſappears; or whether the ſeveral diſtances of it do not make that appearance?

Whether it may not have ſome ſuch propriety, as the Star in *Cete*, whereby it may ſhine and appear for a certain period, and again loſe its light, and diſappear by ſeveral viciſſitudes? and whether that may not give ſome account of the appearance of ſo many Comets about *Aries?*

Firſt, As concerning the matter or ſubſtance of the *Nucleus* Star or body, of the hazy ſhining part encompaſſing it, and of the Tail or Blaze: I ſay, that by comparing all the circumſtances that I was able to take notice of from the beginning to the end, I found that the Star in the head was of a very compacted and denſe light, and almoſt equalled that of *Saturn*; though it were not like that confined by an equal limb: that there were ſome parts diſtinguiſhable in this body, ſome having a brighter, others a fainter light. That theſe parts did not continue the ſame, but conſiderably varied, which might in part be cauſed by the differing poſition of thoſe parts which were ſeen before, from the ſame ſeen afterwards,

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in reſpect of the eye, ſituate on the ſurface of the Earth, moved one way, and the Comet moved another; though I do not conceive it wholly aſcribable to that, but partly alſo to a real alteration of the parts of the Comet. That I did very diligently watch to obſerve if it were poſſible, when it paſs'd over any fix'd Star to find whether it were tranſparent; as I had ſeveral times obſerved the tail of it to be even in its brighteſt parts, but I had not the opportunity; but that I did ſeveral times obſerve the tail of it tranſparent, not only with the naked eye, but through a Teleſcope: if at leaſt the fixed Stars be above it, which I think few doubt, that the light diminiſh'd by degrees towards the extremes of the hazy part encompaſſing it; and yet the extremes of it as to that part of it which reſpected the Sun, ſeemed pretty evenly and ſmoothly defined, eſpecially through a Teleſcope: From all which remarks, and from the velocity of its motion, I conjecture it to be made up of ſolid matter, not fluid; that the body of it eſpecially, is conſiderably denſe, but that the hazineſs or *Coma* about it is much more rarified, and the tail thereof is moſt of all. That this body is encompaſſed with a body moſt fluid, and eaſily permeable, and which doth with very little reſiſtance give way to the motion of it, or any other body through it, that it doth eaſily admit at leaſt (if not actually take into it ſelf) the parts of this body, *Coma*, and Blaze. I ſay, admit at leaſt, (though there may be many reaſons alledged that it doth actually prey upon, and diſſolve thoſe parts into it ſelf, as I ſhall ſhew by and by) becauſe that we find that the extreme parts do extend but to ſuch a diſtance, and beyond that there is no appearance of light, and that the light is from it ſelf, and not produced by refraction or reflexion of the beams of the Sun, I ſhall ſhew reaſons by and by. And conſequently, where there is moſt light appears, there are the greateſt number, and there is the greateſt denſity of the Cometical parts. The middle of the body may be as

denſe as the body of the earth; and I have not obſerved my ſelf, nor met with any body elſe that hath taken notice of any thing to the contrary: If I could have ſeen any Comet to have covered any Star in its way, it would have afforded a very circumſtantial information, eſpecially if for this purpoſe it had been taken notice of with a good Teleſcope. What the denſity of the innermoſt parts of this Earth we live on is, none knows; for though we find the parts on which we tread to be very compact, and though by the induſtry of Miners it hath been proved ſo alſo to the depth of many hundred foot, as *Georgius Agricola* relates: and though it hath been found ſo even to a greater depth by the ſoundings of the bottom of the Sea, yet none can bring an undeniable proof that the ſame is ſo ſolid to 25 miles deep; much leſs that it is ſo to the center: if therefore the external ſhell of this Globe were broken, and removed, 'tis not impoſſible but that the middle parts thereof may be of the ſame nature with the middle parts of the Comets body; and that thoſe parts (were the ſuperficial parts or ſhell removed) might, like theſe of Comets expand themſelves into the encompaſſing Æther. Nay we find, that notwithſtanding the compactedneſs of the ſuperficial parts of this Earth, yet the Æther is able to take up into it ſelf vaſt quantities of them, and to keep them ſuſpended, ſome of them, even to the height of many miles, if any argument may be drawn from the height or length of the dawning or *Crepuſculum*; and this, notwithſtanding the attraction of the Earth in its perfect vigor, or the gravitation of theſe parts thus taken up, or their endeavour towards the center of the Earth. How much more freely then might we imagine the encompaſſing Æther to prey upon, and take up into it ſelf the internal parts, if they were of a looſe and pervious texture, and almoſt in a ſtate of fluidity, like a heap of Sand, or a veſſel of Alabaſter-duſt in boyling, and were not ſo firmly united by the bonds of gravity, and the *vinculum* of petrifaction,

ction, as we find the ſuperficial parts of the earth now are. There is one argument to prove to us, that there may be ſuch a looſeneſs of the internal parts of the earth, and that is that the magnetical virtue varies, which virtue without controverſie diffuſed through the whole body of the Earth, and which hath a relation to the whole Globe, and to every magnetical part thereof. For by obſervation 'tis found, that the magnetical virtue acts upon a needle without it, as the magnetical virtue of a round Loadſtone doth on a Needle applied without that, which, as I may elſewhere ſhew, hath a reſpect to the center of the ſtone differing from all the reſpects that Authors have hitherto aſcribed to it, even of *Gilbert*, *Kepler*, *Kircher*, *Deſcartes*, and our Countryman Mr. *Bond*, who I think was the firſt man that endeavoured to reduce the variations obſerved by *Wright*, *Gellibrand*, *Coſter*, &c. into a Theory and calculation. Now this magnetical virtue, (which may be called one emanation of the *Anima mundi*, as gravity may be called another) being diffuſed through every part of it, and ſeeming to be, as it were *Tota in toto & tota in qualibet parte*, and to be more ſpiritual, and to act more according to Magical and Myſtical Laws than Light, Sound, or the like, it giving to every magnetical body, and every piece of it, though infinitely divided, the ſame proprieties it hath it ſelf; This magnetical virtue, I ſay, having ſuch a relation, and being forced thus to vary, 'tis very probable that the internal parts to which it hath a reſpect, have a variation likewiſe; and conſequently, that theſe internal parts which are ſuppoſed generally very denſe, compact, and very cloſely and ſolidly united, may be notwithſtanding more looſe, and ununited, and movable from certain cauſes.

To proceed therefore, I ſay, that it ſeems very probable to me, that the body of Comets may be of the ſame nature and conſtitution with that of the internal parts of the Earth, that theſe parts may, by the help of the

Æther, be ſo agitated and blended together, as to make them work upon, and diſſolve each other in the ſame manner, as we have often had examples of ſome of the parts of the Earth; a late inſtance of which was at *Mongibel* or *Ætna* in *Sicily*, where the Fire continued for a long time, and produced very conſiderable effects. That this internal agitation may confound the gravitating principle, and ſo leave the parts in a greater freedom to be diſſolved by the encompaſſing Æther, which is the agent that ſets the other two at work to deſtroy each other, that it may at length prey upon both, and diſſolve them both into it ſelf; and conſequently, not only the parts thus diſſolved are elevated to a greater diſtance from the center of the Star or *Nucleus*, or the ſuperficies of it, whoſe gravitating or attractive principle is much deſtroyed, the *Coma* being in this Comet four or five Diameters of the Star or *Nucleus*: but having given thoſe parts leave thus far to ramble, the gravitating principle of another body more potent acts upon it, and makes thoſe parts ſeem to recede from the center thereof, though really they are but as it were, left behind the body of the Star, which is more powerfully attracted than the minuter ſteaming parts: for, I ſuppoſe the gravitating power of the Sun in the center of this part of the Heaven in which we are, hath an attractive power upon all the bodies of the Planets, and of the Earth that move about it, and that each of thoſe again have a reſpect anſwerable, whereby they may be ſaid to attract the Sun in the ſame manner as the Load-ſtone hath to Iron, and the Iron hath to the Load-ſtone. I conceive alſo that this attractive virtue may act likewiſe upon ſeveral other bodies that come within the center of its ſphere of activity, though 'tis not improbable alſo but that as on ſome bodies it may have no effect at all, no more than the Load-ſtone which acts on Iron, hath upon a bar of Tin, Lead, Glaſs, Wood, *&c.* ſo on other bodies, it may have a clean contrary effect, that is, of protruſion, thruſting off, or driving away, as

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we find one Pole of the Magnet doth the end of a Needle touched on the oppoſite part; whence it is, I conceive, that the parts of the body of this Comet (being confounded or jumbled, as 'twere together, and ſo the gravitating principle deſtroyed) become of other natures than they were before, and ſo the body may ceaſe to maintain its place in the Univerſe, where firſt it was placed. Whence inſtead of continuing to move round ſome central body, whether Sun or Planet, as it did whilſt it maintained it ſelf entire, and ſo had its magnetical quality (as I may ſo call it) unconfounded, it now leaves that circular way and by its motion (which always tends to a ſtraight line, and would be ſo were it not bended into a curve by the attractive virtue of the central body) it flies away from its former center by the Tangent line to the laſt place, where it was before this confuſion was cauſed in the body of it. In this line ('tis probable) it paſſes from one part of the Heavens to another, and ſo paſſes through the ſpheres of the activity of multitudes of central bodies; in the paſſing through which ſpheres, 'tis not improbable that thoſe parts which by their diſſolution are made of a nature differing from the body in the center, are rather expelled from, than attracted towards it; and ſo being by this diſſolution rarified, and looſened from the middle, and by their acting upon one another, and diſſolution of the Æther made of another nature, after they have every way diſperſed themſelves to a conſiderable diſtance from their proper body, are converted and driven in a way almoſt oppoſite to that expelling body, and ſo continue to be driven away to ſuch a vaſt diſtance, as to make out that prodigious length of the tail or Blaze of ſome Comets (ſuch as was that of 1618. which, as *Kepler* reports, was extended to 70 degrees from the body or head of it) till at laſt they are diſſolved alſo, and commixed with the Æther within them. So that though I ſuppoſe the attractive power of the Sun, or other central body may

draw the body towards it, and ſo bend the motion of the Comet from the ſtreight line, in which it tends, into a kind of curve, whoſe concave part is towards the Sun, by reaſon that there are ſome central parts of it, which are not yet deſtroyed, and ſo retain ſomewhat of its gravitating principle: yet I conceive that all thoſe parts of the Comet which are thus wrought upon by the other, and changed into another ſtate, and are very much rarified, and produce light, are of a clean contrary nature, and recede from the center of the Sun: much after the ſame manner as we find any combuſtible body with us; as Coal, *&c.* where we find that the body of the Coal, before it be reſolv'd into ſmoke, is a very denſe, and very heavy body, and tends to the center of the earth; but the parts thereof agitated by the Air and Æther into ſteams and ſmoke, and thoſe yet farther diſſolved into flame, do tend upwards, and from the center of the earth. Now though one cauſe of the receſs of flame from the center of the Earth be the gravity of the ambient Air. Yet 'tis not impoſſible, but that there may be ſomewhat alſo of poſitive levity conjoyned therewith. Moſt certain it is, that there muſt be a tendency of receding, as well as a tendency of approaching the center of the Earth, and other attracting body. And there may be much ſaid for the ſuppoſition, that the receſs of the pureſt Æther, from the center, is the cauſe of the motion of the groſſer Æther, and of all other bodies towards it, though there are alſo very conſiderable arguments againſt it. But this diſcourſe is not my preſent buſineſs, though it may hereafter be the ſubject of a Lecture in this place; for upon it do depend ſome of the greateſt operations in the univerſe. And as in the Hiſtory of the Creation, we have an account of the production of light, immediately after the making of matter, which is a motion of receſs from the center of the ſhining body. Next that, a Firmament which divided between the waters or the fluids of the one, and the fluids of another part of the

the world. And in the third place, the collections of particular fluids to one center, as the center of the Earth: and laſtly, out of that collection of fluids appeared the dry and ſolid land. So I conceive the moſt proper way of ſpeculating on theſe great productions of the omnipotent Creator, may be to begin with the conſideration of light, or the motion of receſs from the center of a body. Next, with the conſideration of the cauſe of the ſeparating of fluid from fluid, as Æther from Æther, as I may ſo call differing Æthers; becauſe we have not yet diſtinct names in uſe, and the reaſon of their conglobation, the Æther from the Air, the Air from the Water, the Water from Quickſilver, Oyl, or other fluid. Thirdly, the cauſe of the conglobating property of each of theſe fluids when ſeparated, how they accept and embrace *Homogenea*, and reject or expel *Heterogenea*. And fourthly, how they condenſe and ſettle together, and produce a ſolid body: whence proceeds the confirmation of attraction or gravitation, *&c.* But to digreſs no further, but conclude this part of enquiry in ſhort, I ſuppoſe the *Nucleus* or Star of the Comet may be much of the like nature with the central parts of the Earth, Moon, *Mars*, *Jupiter*, *Saturn*, or other Planets, but much impaired in its attractive or gravitating power.

Next, that the *Coma* or Hazy Cloud about it, may be of the nature of the Atmoſphere or Air about the Earth, or the Smoke or ſteams about a heated or burning body, before they are quite kindled, converted into Flame, or diſſolved into the ambient Air.

Thirdly, that the Tail or Blaze is much of the nature of the parts of Flame, though with thoſe differences I conceive, that the parts of theſe ſteams are not ſo cloſe together, as are thoſe of Smoke: nor doth the motion of them, though much ſwifter upwards than that of our Flame, ſerve to make them appear a ſhining line; but being at that diſtance, they appear much ſlower to the eye, and ſo diſcontinue the appearance; whence every

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ſhining particle appears only a ſhining point, though in the parts of flame (where notwithſtanding the motion be much ſlower, yet being nearer, and ſo varying the poſition to the eye much quicker) each of the ſhining parts makes an appearance of a line of light, and all of them paſſing pretty near together, make the appearance of a continued fluid flame; though that indeed be nothing but a great number of ſingle parcels of the burning body, raiſed up in the particles of Smoke. This will appear evident if we conſider the appearances eaſily to be taken notice of in light: for 'tis obvious from multitudes of experiments, that any ſhining body, as a candle or brands end, being moved very quick, makes the ſame impreſſion on the eye, that a line of light doth ſtanding ſtill: And as obvious alſo that any very light body incompaſſed with a dark *medium* appears to the eye under an angle bigger than really it is, and a dark body encompaſſed with a light *medium* much leſs. This any one may preſently find, if he make a ſmall hole through a thin plate of metal, and holding it firſt between the light and the eye, and ſo ſeeing the light appear through it, and then placing it ſo as there is nothing but darkneſs appears through the ſaid hole, for he will plainly perceive that the ſame hole will appear much bigger in the former poſition than in the latter. Upon this account indeed each of the ſhining parts of the Comet ſeems to fill and occupy a much greater ſpace than really it doth: and ſo, as 'tis obſervable in the milky way, a great number of theſe ſmall ſhining bodies though diſperſed at a pretty diſtance one from another, yet by reaſon of the imperceptibleneſs of each of them they all ſeem to coaleſce into a ſtream or Blaze of light, the brightneſs of which is yet farther augmented by a clear and unenlightened air, and by ſuch a part of the Heaven wherein there appears feweſt of the Stars, whether they be greater or leſſer.

To the Query, *Of what magnitude the Body*, Coma, *and Blaze of Comets may be?* No anſwer can be given until another queſtion be firſt anſwered; and that is, *What is the place of Comets, and what is their diſtance from the Earth?* It was the opinion of moſt Modern Writers before *Tycho Brahe* and *Kepler* (I know divers of the Antients thought otherwiſe) that Comets were ſublunary Meteors, drawn up into the higher Regions of the Air, and there ſet on fire, and ſo continued burning till the Meteor were conſumed; and as the matter increaſed, or waſted, ſo did the appearance of the Comet. But this noble *Dane*, and ſeveral others about that time found by accurate obſervations made, that its Parallax was leſs than that of the Moon; and conſequently, that it was farther diſtant from the earth: that it muſt be a body of another magnitude, and nature, than moſt before that time had imagined; and therefore that it ought to be otherwiſe thought of than the generality of mankind believed concerning it. Many had been the attempts of former Writers concerning them, to find out their parallax; and whether from their unaccurate inſtruments, or from their leſs skill and diligence in uſing them, or from an imagination of the ſolidity, and impenetrability of the Cœleſtial Orbs, or from error in their calculations, or from comparing Obſervations made at diſtant places, one or both whereof were unaccurate, or from a prepoſſeſſion of Tradition or common Fame, or from what other cauſe ſoever it were is uncertain; but 'twas generally concluded by them, that all Comets were ſublunary Meteors: and there are not even at this day wanting ſome of the ſame opinion, though for what reaſon I know not. 'Twill be hard to convince ſome of theſe, that the opinion they have hitherto received for good, is not ſo, becauſe they will hardly give themſelves the trouble of examining ſtrictly into the matter: And to underſtand the nature of Parallaxes, and how ſignificant they are in determining the diſtances of bodies from the ſurface of the

Earth, to certain degrees thereof; beyond which, by reaſon of the imperfections in Inſtruments, and Obſervations, and the exceeding niceneſs and curioſity neceſſary, they ſignifie very little. It is not my preſent deſign to explain what Parallax is, that I would ſuppoſe my Reader to underſtand; otherwiſe there can be no reaſon ſhewn him to convince him that 'tis poſſible to prove that this or that Comet was not nearer than ſo many ſemidiameters of the Earth, nor farther off than ſo many. There are then two ways, by which we may come to ſome certainty of what diſtance a Comet is; and thoſe are, firſt the Parallax of its Diurnal motion, or its Parallax cauſed by the Diurnal motion of the Earth. And ſecondly, the Parallax of its proper motion compared with the Periodick or Annual motion of the Earth. The firſt of theſe may be obſerved two ways; either by two Obſervers at parts of the Earth very far diſtant from each other, but as near as may be under the ſame Meridian: as ſuppoſe the one in *London*, the other in St. *Helens*; both conſpiring in their obſerving of the place of the Comet amongſt the fix'd Stars at the ſame time. Or ſecondly, by one Obſerver in the ſame place, by obſerving the place of it amongſt the fix'd Stars, in its riſing or ſetting, and in a greater, or if it may be, its greateſt height: The noble *Tycho* by very accurate Obſervations of the Parallax, proves the Comet of 1577. to be above the Moon. *Kepler* by his own Obſervations proves that of 1607. at its beginning to be four times farther diſtant; and I doubt not but ſome may have been above forty times farther. But I do not yet find that any Obſervations have accurately determined that which is indeed the great help by which we are inabled to judge of the nature, and all the other accidents and proprieties of Comets. The *Ariſtotelian* Philoſophy for a long time prevailing, made the world believe them to be nothing but Exhalations from the Earth, drawn up into the higher Regions of the Air. But *Tycho* by his Obſervations of their Parallax, raiſes them

them out of that confinement, but yet he ſeems to place them in an Orb about the Sun. But *Kepler* frees them from that confinement, and aſſigns them the Univerſe to expatiate in. But none of all theſe do accurately prove the true diſtance of them, their Parallax being for the moſt part ſo very ſmall, that I fear Inſtruments with common lights will hardly reach them. But we muſt expect from future obſervations made with Teleſcopical Inſtruments to receive a certain Anſwer to this Query. Certain I am, that the Comet which began to appear in *November* 1664. and diſappear'd in *March* following, was far removed beyond the diſtance aſſigned by *Kepler*. For by my own Obſervations divers times repeated, I could not find any ſenſible Parallax, though I endeavoured by a new method to make my Obſervations more accurate. Now though I had not the convenience of making uſe of a Quadrant, or any ſuch Inſtrument, to obſerve its place when near the Horizon, yet the way I took, would, I think, be as good; which was this: With a very good ſix foot Perſpective-glaſs or Teleſcope, I obſerved the place of the Comet, in reſpect of the adjacent ſmall Stars, as ſoon as it appeared, and ſo traced its way till it diſappeared in the vapors of the Horizon: the like I did ſeveral other days ſucceſſively, taking notice by what degrees, in what times it made its progreſs, to ſee whether by its Parallax, when near the Horizon, it would have been depreſt below that line of its motion, which it kept, when at a greater height above it. But though I tried this ſeveral times, yet I was not able to diſcern that the Parallax of it cauſed either any ſenſible bending of the line, or any ſenſible inequality in its progreſs, by which I ſhould have ſooner found it, than by taking its altitudes with common Inſtruments: though I confeſs theſe Obſervations were made when the motion of the Comet was ſlow, and conſequently, when in probability it was far diſtant from the earth. To me there ſeems no doubt but that it was a long way removed above the Moon

when I made these Observations: for had it been of an equal distance with that they allow the Moon, it must this way have manifested a very sensible Parallax of divers minutes: but whereas I could not certainly distinguish any sensible at all, it must be many times higher than the Moon. Now that this way is abundantly to be preferred before an Observation made with a Quadrant for the taking of its altitude, is pretty evident; becaus, by this means the greatest part of the irregularity, caused by the refraction or inflection of the Air is removed; for by this means, though the Parallax be very large, yet the refraction or inflection of the Air will not amount to many seconds, both the objects being almost equally raised by refraction, especially when 5 or 10 degrees high; nearer than which the small Stars vanished out of sight by the thickness of our air. It follows therefore that a Semidiameter of the Earth must be a very inconsiderable measure in its distance.

This part therefore of the Theory of Comets hath been much defective hitherto. If we enquire the Parallax of them from the Observation of divers men made in differing places. we shall find them so differing one from another, that there is great reason to suspect them all: Nay, not only so, but in this Comet of 1664. by comparing two Tables or Charts of the Stars, and Constellations of that part of the Heavens, through which the Comet past, on which was also markt out its way and place from day to day, both of them Printed from Copper Plates, I find that strange errors and mistakes may be created, notwithstanding all the Authors care and accurateness possible, from the carelesness or neglect of the Graver: This I noted in the two Tables of the learned and accurate Mathematician, *P. Ægidius Franciscus de Gotignies*, (whose skill and care from other works of his and other Observations of this Comet I am sufficiently assured of) and found that by the first table upon the $\frac{21}{31}$ of *December*, 1664. it was

was in $4\frac{1}{2}$ of ♈ in Longitude, and in $33\frac{2}{3}$ of Southern Latitude; but by the ſecond it is placed at the ſame time in 4° ♈ for its Longitude, and in $34\frac{1}{2}$ of South Latitude. And this error is not only committed in the place of the Comet, but alſo in the place of the fix'd Stars: for *Riget* in the firſt Table is placed in $30\frac{1}{4}$ South Latitude, and in $12\frac{1}{4}$ ♈ for Longitude, but in the ſecond in $31\frac{1}{2}$ South Latitude, and in 11 $\frac{1}{2}$ ♈ for Longitude: both which differ conſiderably from the place of it aſſigned by *Riccioli* and *Grimaldi*; according to whoſe Obſervations it ſhould be in 31. 11′ South Latitude, and 12°. 11′. 40″. ♈ in Longitude.

Now if there be theſe differences to be remarked in the Obſervations of one, we cannot but expect that much more diſagreement ſhould be found between thoſe which have been made by differing perſons in differing places, and with differing ways, and differing Inſtruments. And upon examination I have found it no better: for from comparing ſuch Obſervations as I have received from ſeveral parts of the world, even of thoſe which have ſeemed more than ordinarily exact, I find them for the moſt part ſo unaccurate, that though they ſufficiently manifeſt that the Comet of 1664. which laſted above four months, was viſible in moſt parts of the world, and ſeen to paſs in all thoſe places pretty near in the ſame way amongſt the fixed Stars. Yet they are ſo far from manifeſting the Parallax, that ſome of them make the place of the Comet to be quite contrary to what Parallax would make it; ſome of the Southern Obſervators placing it much more Southwardly than thoſe of the North. Others indeed of them make the Parallax ſo great, that one might gheſs it to be not ſo far removed from the Earth. Something indeed in the general might be gheſt of the way of that Comet amongſt the fix'd Stars, eſpecially when it approaches them pretty near: but for exactneſs of Calculation for Parallax, they were no way uſeful. And even

in the former uſe too it ſeems very doubtful for comparing the Charts of the Comets way amongſt the fix'd Stars publiſhed by that diligent and unwearied Obſerver Mr. *Hevelius* of *Dantzick*, the above-mentioned *P. Gottignies*, Profeſſor at *Rome*, and Monſieur *Petit* of *Paris*, I find, that the two former make the way of the Comet to lie below the Star in the Bill of *Corvus*; whereas the later, though in a Latitude interpoſed between the parallels of the former, makes it to lie above, or to the North of it: and with him agree ſome Obſervations which I have ſeen of Monſieur *Hugenius*. Other differences I found between thoſe Tables in the way of the Comet of 64. near the middle of its arch; wherein Monſieur *Hevelius* all the way places it more Southward than either Monſieur *Petit*, or *P. Gottignies*: for whereas both *P. Gottignies*, and Mounſieur *Petit* make it paſs above the Star of the third magnitude in the right ſhoulder of *Lepus*, Monſieur *Hevelius* makes it move below it, which ſeem to be aſcribable to Parallax. But I fear much cannot be concluded of certainty from them.

I ſhall not trouble the Reader with a multitude of other Hiſtories, which I have received concerning that Comet of 64. nor with the diſagreements of them one with another, and perhaps of moſt with the truth. They have given me ſufficient trouble in the examination of them, having little other benefit from them, ſave only this, that I was thereby informed what a man might think of a great number of Aſtronomical Obſervations that have been made: for, ſaving the exact Obſervations of ſome few ſuch, as Mr. *Hevelius*, Mr. *Aurout*, *P. Gottignies*, *&c.* truly diligent and accurate men, the greater the Collections of Obſervations are, the more trouble and difficulty is created to the Examiner; they not only confounding one another, but perplexing thoſe alſo which are real and perfect.

Now the reaſons or cauſes of theſe inconveniences ſeem to be theſe.

Firſt,

First, the want of accurate and knowing Obſervators.

Secondly, The ſcarcity of convenient Inſtruments.

Thirdly, The Imperfection of the Tables of the fix'd Stars.

For the Obſervators, 'tis not enough to know how to manage an inſtrument, or to have a good eye, or a dextrous and ſteady hand; but with theſe there muſt be joyned a skilfulneſs in the theorical and ſpeculative part, and add to all a love and delight in the thing it ſelf; and even all theſe will ſignifie but little, without convenient and accurate Inſtruments, ſuch as may be eaſily manageable and ſufficiently exact.

The firſt of theſe the love of the ſtudy being in it ſelf the moſt excellent, or the encouragement of Princes, Noblemen, and other Patrons of this Learning muſt procure: and where both of theſe concur, thence moſt is to be expected, and moſt fruit hath hitherto been proceeded; though there are not wanting divers eminent inſtances where the firſt reaſon hath been the only inducement.

As to the ſecond, I have already in ſome of my former Lectures deſcribed ſeveral convenient ones for theſe purpoſes; and therefore I ſhall not here add any more concerning it.

But as to the third, I hope the indefatigable labour and skill of Monſieur *Hevelius* will ſhortly ſupply the preſent defect, though it had been much to be wiſh'd, that the Inſtruments he had made uſe of had been fitted with Teleſcopical ſights. Theſe Tables, if well done, will alone (as to the buſineſs of Comets at leaſt) ſupply the place of all other Inſtruments almoſt, ſave only a thread, eſpecially if they be ſo delineated in Tables after the Tangent projection, as that the minutes of every degree may be very diſtinguiſhable, which will not ſwell the Maps of the Heavens into an extraordinary large volume, and may poſſibly be the cheapeſt Inſtrument for this purpoſe an Aſtronomer can be furniſhed withal:

withal; for having ſuch a volume of Tables, it will be very eaſie with a thread and one's eye, ſcreen'd only with a ſpectacle made of a thin plate of Braſs, with a ſmall hole through it, inſtead of a glaſs, to obſerve what place the Comet poſſeſſeth amongſt the fixt Stars: for having by the help of the ſaid thread obſerved what two Stars lie in the ſame line with the Comet on one ſide of it, and what other two Stars lie in a line with it, which is at right angles (as near as may be) with the former line, by finding out thoſe four Stars in the Tables, ordered according to the Tangent projection, and with a Ruler, drawing lines over them reſpectively, where thoſe lines do interſect, there will be the true place of the Comet, from which it will not be difficult to find out the true Longitude and Latitude of it by a Sector with Tangents. Now as theſe Tables of all the fixt Stars viſible to the naked eye, would ſerve for finding its place whilſt very big and ſwift of motion; ſo the like Tables of the ſmall Teleſcopical Stars that lie near its way, when almoſt diſappearing, and moving very ſlow, will by the help of a pair of meaſuring Compaſſes placed within the eye-glaſs of the Teleſcope, and a ſtraight line or hair drawn croſs it, ſerve to find the true motion and way of it, when only viſible with a Teleſcope: according to which method I made the annexed Schemes, and Obſervations of the laſt appearances of the Comet.

Now ſince neither from my own, nor from any other Obſervations that I have hitherto met with, there can be any certain concluſion drawn of the diſtance of theſe Comets, ſave only this, that their diſtance was very great, and much higher than the body of the Moon, becauſe elſe there muſt have been a conſiderable Parallax cauſed by the Diurnal motion. The next enquiry will be, what other ways there are of knowing its diſtance. Now though none could be more demonſtrative than the Parallax found this way by the Diurnal motion, yet there are ſome other which ſeem more eaſie

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ariſing from the conſideration of the motions that may be thought to be concern'd in the producing the appearances. And though they be wholly hypothetical, and ſo need ſome other arguments to prove the ground and principles on which they are founded, yet ſince there are not very many conſiderable ones wanting to make them probable and rational, I ſhall here add ſomewhat of my inquiries after the diſtance, poſition, motion, magnitude, *&c.* of theſe Comets by theſe means.

Of theſe ways there are ſeveral depending upon ſeveral ſuppoſitions which produce very differing effects, as to the magnitude, diſtance, motion, and way of the ſame Comet.

The ſuppoſitions are theſe:

Either that the Earth moves in an annual orb about the Sun, as the Sun is ſuppoſed by others to move about the Earth: Or that the Earth is perfectly fix'd, and hath no ſuch motion.

Next, that the Comet moves either in a ſtraight line, or in a curve line; and the curve is either a circle, or ſome other regular or irregular curve.

Further that the motion of the Comets in theſe lines is either by equal or unequal ſpaces in equal times.

Now according as we take this, or thoſe of theſe differing ſuppoſitions, and compound them together, ſo will the product of them be ſtrangely differing. Amongſt the great variety of compoſitions of theſe principles or ſuppoſitions, theſe ſeem the moſt ſimple, and conſequently being any otherwiſe proved, will beſt determine the true diſtance and way of the Comet.

Firſt, To ſuppoſe the Earth to ſtand ſtill, and the Comet to move equal ſpaces in equal times in a circle.

Secondly, To ſuppoſe the Earth to move in an annual Orb about the Sun, and the Comet to move through the Æther or *Expanſum*, equal ſpaces in equal times in a ſtraight line.

Thirdly, To ſuppoſe the Earth to move (as above)

in its annual Orb, and the Comet alſo to move equal ſpaces in equal lines in a circle.

The other are indeterminate and infinite, and nothing can be concluded from them as to the diſtance, magnitude, motion, *&c.* of Comets; for the line or way of the Comet may be placed at any diſtance, if we will ſuppoſe it moved in an uncertain curve, with unequal degrees of velocity: And indeed, upon a ſuppoſal of an inequality of motion, nothing of its way or diſtance can by any of theſe ſuppoſitions be found out. This fault had that of *Tycho Brahe*, where he ſuppoſed an unequal motion of it in its Orb about the Orb of *Venus*, which was founded upon the firſt Hypotheſis, but had introduced into it ſome inequality of motion; beſides his own ſuppoſition, that it was moved about the Sun, and the Sun about the Earth. See the fifth Figure. *Keplers* way, which was after the ſecond Hypotheſis, had the ſame fault; for he ſuppoſed the annual motion of the Earth, and the motion of the Comet in a ſtraight line, but introduces an acceleration of motion in the Tangent towards the latter end.

The third way I have here taken, and from the beſt obſervation I could meet with, I have delineated its reſpects or angles to the Sun: and accordingly ſuppoſing it to move equal ſpaces in equal times, in a curve which for ſo much of it as the Comet was obſerved to paſs was very near a Circle, I found this Circle would fall as it is expreſs'd in the ſeventh Figure, where 'tis obvious to take notice, that when the Comet was neareſt to the Earth, namely, about the 19. or 20. of *December*, that it was not nearer than an eleventh part of the diſtance of the Sun; that on the 23, it was twice as far, that on the 29. it was four times as far; that on the 15. of *January* it was as far as the Sun, and on the 14. of *February* it was above twice as far diſtant as the Sun. That this way or Orb of the Comet is here bended ſo as (if it were an entire Circle;) one part of it would

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go without the Orb of *Jupiter*, as the other which is here delineated comes within the Orb of the Earth; that the plain of this Orb is inclined to the plain of the Ecliptick about 18 degrees, that if from ſeveral parts this Orb perpendiculars be let fall upon the Plain of the Ecliptick, thoſe perpendiculars ſhall fall in an Ellipſis, part whereof ſhall fall within the Orb of the Earth in ♋, and the oppoſite without the Orb of ♑ in ♒. That the Comet moves a Sextant of this Orb in about 130 days, and conſequently if its motion ſhould continue the ſame in ſuch a Circle, it would appear about *February*, *March*, or *April*, 1667. but being ſo far removed towards the South Pole, will here hardly be ſeen: but by thoſe that live towards the South, it may appear to have ſome ſuch motion by the South Pole, as that of 1618. had by the North. And 'tis not impoſſible, but that the Comet of 1618. might be the ſame with this, if we ſuppoſe the Nodes of it to have a motion contrary to the order of Signs: and that the ſame Node which in this Comet, according to this ſuppoſition was in ♊, was then about ♍ or ♐: but theſe as conjectures I ſhall not inſiſt on, becauſe neither in this, nor in that have we Obſervations ſufficiently accurate to build any Theory upon. Now though upon theſe ſuppoſitions the motion and appearances of the Comet ſeem to be very regularly, and very naturally made out, yet 'tis not the only Hypotheſis for that deſign: nor do I believe it ſo evident a demonſtration for that end, as ſome would ſuppoſe; though for other reaſons I am apt enough to think that opinion of the Earths motion very probable: but the motion of this Comet is ſo well made out, by the contrary ſuppoſition, that I think it may be alledged for a greater argument againſt the motion of the Earth, than for it: for if we only grant one of the former *poſtulata*, namely, that the body of the Comet is moved equal ſpaces in equal times, and a quite contrary *poſtulatum* to the former; namely, that the Earth remains fix'd as to an annual motion, we may

find all the obſervations of this Comet, eſpecially the moſt accurate of them, to happen ſo, that the Comet being ſuppoſed to be moved in a great Circle, whoſe convex ſide is turned towards the Earth, whoſe center is extended towards the fix'd * in ♋; and whoſe Semi-diameter is about ſixſcore times the neareſt diſtance of the Comet from the Earth, and the Comet be ſuppoſed to be moved very near equal ſpaces in equal times, we ſhall find, I ſay, all the appearances moſt exactly ſolved, and indeed much more exactly than by the other ſuppoſition I was able to find any; for by this ſuppoſition both the magnitude, longitude, latitude, retrogradation, ſtation, and direction of the Comet is moſt exactly made out as any one might have found that ſhould have by this means examined with me the obſervations I have hitherto either made or met with: and indeed all the Obſervations hitherto have ſo well anſwered this Hypotheſis, that I do almoſt promiſe my ſelf to be able to ſee this Comet a month or ſix weeks hence, after the Sun has paſt by it; if by its exceeding elongation it be not quite grown out of ſight, as it is now indeed already ſo exceeding dim, and faint, that it cannot be ſeen without a very good glaſs, which will endure an exceeding big aperture: nor could I theſe two laſt nights perceive it, though the Air were clear; but the reaſon I attribute to its nearneſs to a fixed * of ♈: This Hypotheſis is explained in the ſeventh Figure. By this ſuppoſition the return of the Comet will be much longer, and the time of ſeeing of it much more uncertain; becauſe the curvature is ſo little that the making the circle a twentieth, or a ſixteenth part bigger or leſs, does not much alter the regularity; whence 'tis exceeding difficult, unleſs we had much more accurate Obſervations than I have hitherto met with, to determine exactly the bigneſs of the circle, and conſequently the time of the return. And by this ſuppoſition the Comet may be ſuppoſed either nearer or farther from the Earth at any diſtance, which is not con-

contradicted by a Diurnal Parallax; that is, it may be ſuppoſed either above *Saturn*, or below the Moon, or in any place between; by ſuppoſing only, that the farther the neareſt part of the Circle is diſtant from the Earth, the greater muſt that Circle be, and the ſwifter the motion of the Comet in it: to prove which affirmation, let in the Eighth figure A be the Earth, B C D the Orb of the Comet ſuppoſed very near the Earth, and E F G the Orb of it ſuppoſed at a greater diſtance: let H be the center of B C D, and I of E F G, and let A C, be to C H, as A F, to F I, all the lines drawn from the point A, ſo as to cut the Circles B C D and E F G, ſhall divide thoſe Circles E F G, and B C D, into ſimilar ſegments: as let A B E be a line drawn cutting thoſe Circles in B and E: I ſay, the Arch B C ſhall be ſimilar to E F. In which Hypotheſis if we have together with the place of the Comet when ſtationary, the place of it when in its greateſt celerity, perige, or the places of it when of the ſame celerity on each ſide of its perige, we have from thence the proportion of the Radius of its Orb to the perigean diſtance, and conſequently all the other diſtances, the line in which it appears when ſtationary, being the Tangent to the Circle in which it moves, as A B E, to which a Perpendicular raiſed at B B E, and produced till it cut the line A C, (produced) at H H I, it gives the Center of its Orb H H I, and the proportions of the lines A B, A C, B H = H C, or of A E, A F, E I = F I, the Angle B A C, being given by obſervation. So that by this Hypotheſis the Phænomena of the motion and bigneſs of the Comet will be ſolved, though ſuppoſed of any diſtance. Nor are theſe the only Hypotheſes by which the hitherto obſerv'd Phænomena may be ſolv'd: for if we will admit an unequal motion, ſuch as is now granted to all the Planets: and if further we will admit it to be moved in an Elleipſis, or other ſuch like curve, there may be divers other Hypotheſes that will ſolve the Phænomena; ſo that the Comet may be ſuppoſed to

have no motion at all as to Longitude, but only as to Latitude: that is, it may be ſuppoſed to be moved in an Elleipſis, deſcribed in a plain which ſhall be at right Angles with the plain of the Ecliptick, and the ways of the Earth in it: it may be ſuppoſed alſo to have been mov'd direct, according to the order of the ſigns, that is, to have been firſt about *Gemini*, in reſpect of the Sun, and to be now in ſome part of *Leo:* And it is not impoſſible to ſolve the phænomena of its periodick or proper motion, though it be ſuppoſed not ſo high as the Moon, and that the motion of the Earth paſſing by it did really alter its motions, had there not been made ſome Obſervations about the Parallax of it, which prove it higher: ſo that according to this or that Hypotheſis which we take, the time of its return, if permanent, will be longer or ſooner.

And theſe Hypotheſes may be ſo various, that till regulated by very exact Obſervation of the Parallax, 'tis not to be hoped that the appearance of a Comet can be certainly predicted: So that I fear the prophetick ſaying of *Seneca*, *Erit qui demonſtret aliquando in quibus Cometæ partibus errent, cur tam ſeducti à cæteris eant, quanti qualeſque ſint*, will hardly be verified at this time by the help of this preſent Comet. Though in truth I cannot find by the examination of ſeveral of them, but that they all ſeem to promiſe very fairly a return of it: for all the Calculations I have hitherto made of its motion, ſeem to caſt it into a circular, and not a into ſtraight line, as *Kepler* ſuppoſed; and indeed upon examining even *Keplers* own Calculations of thoſe Comets which he obſerved, and has endeavoured to make to move in a ſtraight line, I cannot find that any of them will be found to move equally in ſuch a line: but to ſolve the appearances, he is fain to make them move in ſuch ſuppoſed ſtraight lines, by a line of Tangents, that is, to make the motion of Comets accelerated the further they are moved; all which Phænomena may be very eaſily ſolved by ſuppoſing them to have moved equal ſpaces

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in a curve or circle. The phyſical reaſon indeed ſeems pretty difficult, by what means it ſhould be confin'd or bound ſo as to move in a Circle: but this is no more than is uſually ſuppoſed in all the Planets, and without ſuppoſing a kind of gravitation throughout the whole Vortice or *Cœlum* of the Sun, by which the Planets are attracted, or have a tendency towards the Sun, as terreſtrial bodies have towards the center of the Earth. I cannot imagin how their various motions can with any ſatisfaction be imagined, but that being granted (for which had I now time, I could alledg many reaſons, and may do it hereafter on another occaſion) not only the reaſon of all the irregular motion of the Planets may be eaſily found, but the reaſon alſo of the ſtrange and various motions of the Comets. The reaſon why its Beard is for the moſt part oppoſite to the Sun, which was another Query, of which I have already ſaid ſomewhat of my ſuppoſitions, and ſhall now add, that the brighter ſpot or kernel in the middle did ſeem to be ſome kind of body, which though it be not actually burnt, may yet by the encompaſſing fluid Æther be diſſolved and waſted, and thoſe diſſolved parts may aſcend upwards, or from the center of the Sun, (which ſeems indeed to be the center of gravitation throughout the whole ſyſteme of it.) To illuſtrate which explication, I could produce ſeveral experiments which would make a perfect repreſentation of the phænomena of the body, and beard of the Comet: I ſhall only inſtance in one. Take a very clear long Cylindrical Glaſs, which may hold about a quart of water; fill it three quarters full with water, and put into it a quarter of a pound of Oyl of Vitriol, and in the midſt of this ſuſpend by a ſmall ſilver wire, a ſmall wax-ball, rould in filings of iron or ſteel, and you may plainly obſerve a perfect repreſentation of the Head, Halo, and Beard of the Comet; for the *menſtruum* falling on, or diſſolving the iron, there is a continual eruption of ſmall bubbles, and diſſolv'd particles from all the

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ſides of this body; and after the eruption they all aſcend upwards from the center of the earth; for being of a much lighter conſiſtence than the anbient liquor, they are by the greater gravity of that, continually protruded upwards. The ſame appearance may be made with any kind of *menſtruum*, and a convenient diſſoluble body ſuſpended in it; ſo that if we ſuppoſe the Æther to be ſomewhat analogous to a *menſtruum*, and that there is a gravitation towards the center of the Sun, if the *Nucleus* or head of the Comet be ſuppoſed ſuch a diſſoluble ſubſtance, the phænomena of the ſhape of the Comet may, I think, be rationally explained. Now that the Æther may have ſuch a kind of propriety, ſeems to me to be argued from this, that the Air about the Earth ſeems to owe its original to it, it being only a diſſolution of terreſtrial bodies into the Æther, the Æther being the principal fluid body, and greateſt part of this diſſolution; and the ſubſtance of the Air, ſome very few and ſmall ſaline and earthy particles: of which elſewhere. By this Hypotheſis the phænomena of the Comet may be ſolved; for hence 'tis eaſie to deduce the reaſon why the Beard grows broader and broader, and fainter and fainter towards the top: why there is a Halo about the body; for this will appear clearly in the experiment: why the Beard becomes a little deflected from the body of the Sun; for if the diſſolving Ball be by the wire mov'd either this way or that way, the ariſing ſtream or bubbles will bend the contrary: and to countenance this ſuppoſition, both in thoſe Comets obſerved by *Tycho*, *Kepler*, and alſo in this laſt the beard was contrary to the motion; ſo that the head or body going faſter, ſeemed to leave the beard or tail ſomewhat behind: by this ſuppoſition alſo 'twill be eaſie to explicate why the beard is ſometime bended, and not ſtraight, and why it is ſometimes brighter upon one ſide than upon another? why the bottom of it is more round, and the other ſides more undefin'd; and divers of the like phænomena. Againſt this

this ſuppoſition it ſeems difficult to conceive whence ſo vaſt a body ſhould be generated; next, how it ſhould be able to ſupply ſuch a conſtant ſtream of aſcending parts, and yet laſt ſo long as this has done, almoſt a quarter of a year. Thirdly, Whence ſuch a newly generated body ſhould receive ſo great a degree of motion. In anſwer to which, I ſay, 'tis not impoſſible but that the body of it may be as old as the world, and that it may have then received its firſt determination, or laws of motion, and may have ever ſince preſerved them, that it may have been all this time alſo in diſſolution, and yet not be quite waſted; and that it may continue yet for many ages before it be quite diſſolved into the Æther. And to make this probable, divers experiments and reaſons might be alledged; as that of the ſlowneſs of the waſting of many bodies, by the diſſolution made on them by the fire: the ſlowneſs alſo of the diſſolution of multitudes of bodies in *menſtruums*. And I have already ſhewn how ſmall a quantity of diſſolved particles will be able to make as great a ſhew of light: beſides that, the motion of the aſcending ſtream or beard being but ſlow, there needs no very quick ſupply of other parts. We ſee alſo into what a vaſt quantity of ſmoke a ſmall parcel of a combuſtible body may be turn'd. From all which particulars, 'tis not unlikely but that the Comet may be a body moved with a regular circular or elliptical motion as the Planets are, that it may be a body of ſuch a conſtitution, as that the fluid Æther through which it paſſes, may diſſolve it much after the manner as a *menſtruum*; (ſuch as *Aqua fortis*, Spirit of Niter, *&c.*) does a diſſoluble body; that by this means there may be a ſlow, but continual eruption of ſomewhat opacous parts, which may by their diſſolution afford a ſufficient quantity of light to make as great an appearance as any of the Comets, that this ſtream or beard may by the reſiſtance of the Æther be a little deflected backwards in the ſame manner as an aſcending ſtream of ſmoke will be by the reſiſtance of

the Air, if the burning body be mov'd this or that way through it, that the body of the Comet may be both as ancient and as laſting as the world; and that this which has lately appeared may have appeared heretofore, and may likewiſe hereafter appear again; that 'tis probable the neareſt diſtance of it was much greater than that of the Moon, that the length of its Beard was longer than its diſtance from the Earth, and conſequently ſeveral times longer than the diſtance between the Earth and the Moon; that its viſible way among the Stars was very differing from a great circle, eſpecially towards the latter end, when it became retrograde; that its way through the Æther could not be ſuppoſed equal in a ſtraight line, though it might be ſuppoſed equal in a curve or circle, that the exact way of it could not be certainly determined by the beſt Obſervations I have yet met with: and that therefore the beſt help we have to gheſs of its way and diſtance, is by its manner of moving, as to appearance among the fixed Stars, which I have already ſhewn to be explicable by various Hypotheſes: for both the Earth and Comet may be ſuppoſed to be moved, either both one way, or contrary ways, or croſs ways, the Earth may be ſuppoſed to ſtand ſtill, and the Comet only to be moved, and the like.

Theſe Requiſites therefore being hitherto wanting in the Obſervations I have met with of this Comet, all that can be ſaid of it will at beſt be but conjectural and hypothetical; ſince nothing can be reaſonably built upon thoſe Obſervations where the truth of them is dubious; wanting therefore ſound materials to work upon in this Comet, I had recourſe to the Obſervations of the noble Dane *Tycho Brahe*, being ſufficiently ſatisfied both of the ability, induſtry, and veracity of that excellent Author, who left nothing unattempted for the perfecting of ſuch Obſervations as ſeem'd to him requiſite for the compleating a Hiſtory of that Comet which appeared in 1577. And from thoſe Obſervations of his

I endeavoured to trace the way of it according to ſeveral hypotheſes; and found, that ſuppoſing the Earth not to be moved with an annual motion, but only a diurnal about its own Axis, the way of Comets will fall in a line very near approaching the nature of a circle, though neither into an exact circle, nor an exact ellipſe; and therefore ſeems irregular, and not at all probable. Again, ſuppoſing it moved about the Sun, as *Tycho* has done, we find from his Calculation of it, he was fain to allow it a quicker and ſlower motion in its Orbit, to ſolve the Phænomena, which ſeems to me but a ſhift, that will ſerve to help out any lame Hypotheſis whatſoever: And that granted, and the Parallax of the Comet unknown, I will undertake very eaſily to make out almoſt any Hypotheſis, which is the fault alſo of Mr. *Horox* his Hypotheſis, wherein he ſuppoſes the Earth to be moved about the Sun, and the Comet like a Rocket to be ſhot out of the Sun, and by degrees to return to it again; in which Hypotheſis indeed there ſeems to be much more reaſon for an inequality of motion, though not in the manner as he has placed it; 'twas very rational that the motion of it at firſt, if caſt out of the Sun, ſhould be very ſwift; but then it ought likewiſe to have accelerated its motion in the ſame manner in its return back to it again, which it does not in his Hypotheſis; for a ſtone or any other heavy body being ſhot up into the Air, does make its return back again to the Earth, almoſt by the ſame degrees of velocity, by which it aſcended from it: almoſt, I ſay, becauſe the reſiſtance of the Air does ſo far impede the motion of the body through it, that it never ſuffers it to acquire the ſame degree of velocity with which it was firſt ſhot upward. This is ſufficiently evident from a *Pendulum*, which if it be thrown upwards, and be ſuffered to return back, it will never riſe again on the oppoſite ſide to an equal height, with that it deſcended from, on that ſide towards which it was thrown: but beſides, in his Hypotheſis he ſeems to take no notice at

all of the Latitude of the Comet, which ſeemed to carry it much farther off from the Sun, when he ſuppoſes it to be returning nearer. And indeed upon the whole his Hypotheſis ſeems rather a product of chance than of any contrivance. For he in endeavouring to ſet off the Longitude of the Comet according to *Tycho*'s Tables, and to trace its way by ſuppoſing the Earths annual motion, making uſe always of the ſame Radius to ſet off the aſpect, or apparent angle of it with the Sun, his line of Chords he made uſe of did always direct the point of his Compaſſes to the place where he ſituates the Comet, as may be eaſily found by examining the ninth figure; where you may find that he places the Comet always equally diſtant from the Earth, and that diſtance is always equal to the diſtance of the Sun, which has ſo many inconveniencies and improbabilities, that I ſhall not inſiſt farther on it; eſpecially ſince I do not find that he beſtowed any farther pains in explicating or cultivating this his Hypotheſis, than only the bare delineation of this ninth figure. But to return to *Tycho*'s Hypotheſis, if that be true, why did not the Comet again appear after a certain ſpace of time? and why could not he have foretold when it ſhould again appear, as well as he could predict the appearance of *Venus*, about whoſe Orb he ſuppoſes it to circulate? I ſhall paſs by ſeveral other very material objections that might be made againſt that his ſuppoſition, becauſe many of them might be made alſo againſt his Hypotheſis of the Heavens in general, which I ſhall the rather omit, becauſe I do not find he has many followers in that ſuppoſition; the generality of Aſtronomers embracing rather the *Copernican* Syſtem, eſpecially as it is refined and rectified by the ingenious *Kepler*.

Laſtly, I endeavoured to trace the way of the Comet from *Tycho*'s Tables, according to *Keplers* Hypotheſis; which was, that the appearances of the motion of the Comet were aſcribable to two cauſes; namely,

namely, the motion of the Earth about the Sun in its annual Orbit, and the motion of the Comet in a ſtraight line, not accelerated according to the proportion of the increaſe of Tangents; but upon ſuppoſition that it mov'd equal ſpaces in equal times: (for I cannot imagine what reaſon he had to ſuppoſe its motion to be accelerated, and much leſs why he ſhould aſſert it to be according to the proportion of Tangents, which in a little time muſt neceſſarily come to move infinitely ſwift: than which nothing is more hard to be granted.) And I found it after many trials and eſſays to fall in a ſtraight line, inclining to the plain of the Ecliptick by anangle of 47.40. and cutting it in 9 degrees of *Scorpio*, if computed out of the Sun, and moved faſter by half than the Earth in its Orb; and this to ſo great an exactneſs to anſwer all the Obſervations of *Tycho*, that from a very large Scheme which I drew of it on a plain, I could never find many minutes difference; ſo that I concluded that to be the moſt likely Hypotheſis for that Comet, it ſeeming to ſolve all the ſeveral Phænomena of the motion and magnitude of the Comet, with the leaſt imaginable difficulty, and to be moſt agreeable with my phyſical notions of Comets: For, firſt it only ſuppoſes a ſolid body moved in a fluid, with an almoſt direct motion. I ſay, almoſt direct, becauſe for ſome phyſical reaſons, as I have ſaid before, I imagine it not exactly ſtraight, but inflected a little towards the curvity of a circle, which I ſhall preſently endeavour to explain farther in this Comet. Next, it ſuppoſes that body to move in that line almoſt equal ſpaces in equal times; I ſay, almoſt equal, becauſe ſome of thoſe equal ſpaces may be increaſed by an accelerating cauſe or principle, ſuch as that of a gravitation towards the body of the Sun, placed in the center of its Vortice or Syſtem, when the motion of the Comet carries it towards the Sun, and may be diminiſh'd from other impeding cauſes, ſuch as the impediment of the fluid medium through which it paſſes, and the attraction of the

Sun operating on it when its motion carries it farther and farther off from it: beſides, 'tis not unlikely, but that the attraction of the Earth, or ſome of the other Planets may have ſome kind of influence on it, eſpecially, when its line of Direction does ſomewhat nearer approach thoſe attractive points. But the deflection from a ſtraight line is always ſo much the leſs by how much the ſwifter the body is moved, and by how much the farther off its line of trajection is perpendicularly diſtant from thoſe attracting bodies. According to this ſuppoſition of mine, I have endeavoured to make out all the appearances of this laſt Comet, taken notice of in the beſt obſervations I have yet met with, amongſt which I find no one of the Parallax ſatisfactory, as in the tenth figure, let S repreſent the Sun, O R B, the Orb of the Earth, A C D E F, a bended or curve line in which the Comet is ſuppoſed to move: the Comet then coming into the Sphere of the attractive power of the Sun, by the ſtraight line P A G, at A, the power of the Sun worketh on it, and by degrees attracting it towards its own Center by that time the Comet hath moved to C, the attractive power hath deflected its direct courſe from P A G, to C H, and ſo the Comet would continue to move in that ſtraight line C H, but it is ſtill deflected ſo, that at D, it moves towards I, but the gravitation of the Sun attracting it, deflects it from that line towards E, and ſo from E to F, when it begins again to Jet out of the attractive beams of the Sun, and ſo it will continue to proceed, as if it had come to that point by the line M F L, the reaſon of which is the great velocity of theſe bodies, which are generally much ſwifter in their motions than the Earth or other Planets are ſuppoſed to be, in theirs. We muſt ſeek out ſome other way therefore of finding of the diſtance of Comets than the commonly uſed: I ſhall therefore ſomewhat further explain the contrivance I newly invented for this purpoſe, by which not only the Parallax of the Comet but of the Pla-

nets

nets alſo may be found with great facility and exactneſs.

Having a large Teleſcope prepared (as I formerly directed) with Eye-glaſſes capable of taking in an Angle of about two degrees at once, and furniſhed with a dividing Scale, obſerve when the motion of the Comet or Planets is not too faſt, the poſition and diſtances of the ſmall fixed Stars which are next adjoyning to the moved body whoſe Parallax you would find; of theſe ſmall fixed Stars you ſhall ſeldom miſs a ſufficient number, which will be taken into the glaſs at once, if at leaſt the object-glaſs be allowed a very large aperture; and having found ſuch Stars as will be convenient for your purpoſe, be very diligent in taking, by the help of the dividing Scale, the exact diſtance of them one from an other, and when the body is higheſt above the Horizon, *viz.* in or near the Meridian, by the ſame means take the exact diſtance of it from two or three of the neareſt and moſt conſpicuous fixt Stars about it, and by the help of a plumb-line, hung likewiſe within the cell, near the dividing Ruler, find exactly the poſitions of all thoſe bodies you take notice of to the Perpendicular or Horizon, which may be eaſily enough done, if together with a Plumb-line or Perpendicular plac'd within the glaſs you have alſo a ſmall Diagonal thred faſtned to a ring, whoſe circumference is divided into 360 degrees, and moveable ſo as by the finger eaſily to be turn'd any way, by which means this Diagonal thred may be made to croſs over any two of the bodies you obſerve, and by obſerving what diviſion of this divided limb the Perpendicular cuts, it will be eaſie to determine the exact poſition of thoſe Stars to the Horizon; this ſame may be done by the dividing Scale alſo, if that be fixt in a divided Circle which is movable, in the ſame manner as the thred is ſuppoſed to be. This Obſervation, with all other circumſtances of it is likewiſe to be repeated at the ſetting or riſing of the Planet or Comet, and again

gain the next night when it comes to the Meridian, and in each of thoſe obſervations the exact time is to be noted by a time-keeper, and the altitude by ſome of thoſe I have before deſcribed, for by comparing theſe three obſervations together it will be very eaſie to find what irregularity in its motion is aſcribable to its Parallax. And this will be ſo much the eaſier becauſe the examination and reduction of it may be done (with as great exactneſs as the obſervation can be made,) by the help only of Ruler and Compaſſes, for all the diſtances will be ſet off by equal diviſions of ſtraight lines, the line alſo of the periodick motion, whether of the Comet or Planet, eſpecially if the obſervations be made when the body is near an oppoſition with the Sun, which is much the beſt time, will be with ſufficient exactneſs taken for a ſtraight line, and the motion in that line may be ſuppoſed by equal ſpaces in equal times; for the difference between the Tangents of the centeſms of a degree to two degrees is not increaſed much more then $\frac{2}{1745}$ that is not a quarter of a centeſm of the hundredth part of a degree, which is much more exact than I fear our obſervations will ever be.

Another way of finding the Parallax may be by the help of exact obſervations made by ſeveral perſons at the ſame time, in places much differing in Latitude, though as near as may be under the ſame Meridian (becauſe of ſaving the trouble of Calculation, and for being aſſured that the obſervations were both made exactly at the ſame time) each perſon by the help of very long Teleſcopes obſerving the exact diſtance of the body from the ſmall fixt Stars next adjoyning.

A third way of finding the Parallax of Comets is wholly new, and though hypothetical (as ſuppoſing the annual motion of the Earth, and the motion of the Comet in a right line through equal ſpaces in equal times) yet 'tis founded upon a Problem in Geometry (invented by the incomparable Mathematician, Doctor *C. Wren*) which is truly noble and wholly new, and though

though it had been of no uſe in Aſtronomy, deſerves none of the meaneſt places in Geometry, by the help of which (which is much more than either of the other ways is capable of) one may eaſily find the true parallax of the Comet, from any four exact obſervations of it, made at differing times in the ſame place: Nor does it require ſo nice and accurate Inſtruments and Obſervators as are altogether neceſſary in the other ways. The Problem as I received it, is this.

Problema.

Datis quatuor lineis utcunque ductis (quarum nec tres ſunt parallelæ neque ab eodem puncto ductæ) quintam ducere quæ à quatuor primo datis in tres partes ſecetur ratione & poſitione datas.

Sint in Figuris 13, 14, 15, 16, 17, *&* 18, *quatuor rectæ* A D C, B E C, A E, B D, *productæ verſus* K, γ, φ, M, *oportet quintam ducere ut* K M, *quæ ſecetur à primo datis in ſegmenta* K N, N O, O M, *ſecundum datas rationes* R, S, T. *Fiat ut* R *ad* S, T, *ſimul ſumptas ita* C D, *ad* C F. *Rurſus ut* T *ad* S, R, *ſimul ſumptas, ita* E C, *ad* C G, *ductis autem* A G H, B F H, *à mutua interſectione* H, *ducantur* H γ K, H φ M, *parallelæ nimirum lineis* A C, B C, *quæ mediæ interjacent inter extremas,* B D, A E. *Denique inter puncta extremarum* K M, *ducatur Recta ſecans medias in* N O. *Dico ſegmenta* K N, N O, O M, *eſſe in Data ratione* R S T.

Quoniam F D, *parallela eſt ipſi* H K, *ergo ut* C D, *ad* C F, *ita* K γ, *ad* γ H, *& quoniam* γ N, *parallela eſt ipſi* H M, *ergo, ut* K γ *ad* γ H, *ita* K N, *ad* N M, *ergo ut* K N, *ad* N M, *ita* C D, *ad* C F; *ſed* C D, *ad* C F, *eſt ut* R *ad* S, T, *ſimul ſumptas, ergo* K N, *eſt ad* N M, *ut* R, *ad* S T, *ſimul ſumptas. Similiter quoniam* E G, *parallela eſt ipſi* M H, *&* φ O, *ipſi* H K, *demonſtratur* M O, *eſſe ad* O K, *ut* T *ad* S, R, *ſimul ſumptas. Quare tres* K N, N O, O M, *erunt ad invicem ut* R, S, T, *ergo ducitur linea* K M, *cujus tria ſegmenta à quatuor lineis datis intercepta ſunt in data Ratione* R, S, T, *& ſervata quidem*

dem poſitione ſive rationum ordine R, S, T, quod erat faciendum.

From the invention of which Problem 'twill be very eaſie by any four obſervations Graphically to deſcribe, or Geometrically to calculate the true diſtance of the line of the trajection of the Comet, and conſequently to anſwer all thoſe queſtions that can be demanded concerning the bigneſs of the body and head, and concerning the bigneſs and length of the blaze, and concerning the diſtance of it from the Earth in every part of its way when it was neareſt the Earth, when neareſt the Sun, where it cuts the Plain of the Ecliptick, ſeen from the Sun, and where ſeen from the Earth, with what Angle it was inclined to the ſaid Plain, how ſwift the motion was, that is, what length it paſſed, in what time, when it muſt appear Stationary, when Retrograde, when diſappear, and the like.

According to this method I received at the ſame time, (whilſt it yet appeared very viſible to the Eye, and was not Retrograde,) the way of the firſt Comet delineated by the ſaid perſon, which did very near ſolve all the appearances preceding and ſubſequent, which I have therefore here annexed in the Table expreſſed in the 19. 20. and 21. figures, where in the 19. is delineated the Place of the Sun in the Center of the Circle ♈, N, D, I, ♎, which repreſents the annual Orb of the Earth about the Sun, the points between N and D repreſent the places of the Earth in that Orbit in the days of *November*, and the lines drawn from them to the points in the ſtraight line, repreſent the lines in which the Comet appeared in reſpect to the Sun; in like manner the points between D and I, the places of the Earth in *December*, and the lines drawn from them to the ſtraight line, as before the viſible places of the Comet at thoſe times, *&c.* The 20. figure repreſents ſingly the ſeveral Longitudes of the Comet at ſeveral times ſeen from the Earth. And the 21. repreſents the ſeveral Latitudes, at the ſeveral times, together with the true

true diſtances of the Comet at thoſe times, both which are made out of the 19. figure, where E at the end of the line repreſents the Center of the Earth, from which to the figures in the prickt curve-line, are the true diſtances of the Comet, the Perpendiculars from thoſe figures to the line E C are the Signs of the Latitude of the Comet from the plane of the Ecliptick E C, the aforeſaid diſtances being made the Radii.

Now though according to my former Delineation the Comet ſeemed to take a circuit, as if it would within three years return to its former poſition, yet I am not wholly convinced that it moves in a circle or Ellipſe, but I rather incline to the incomparable *Keplers* opinion, that its natural motion tends towards a ſtraight line, though in ſome other ſuppoſitions I differ from him.

As firſt that the Comet perſeveres exactly in a ſtraight line. Secondly, that after it has paſt its Perige it accelerates its motion in proportion to Tangents of equal Angles. Thirdly, that it either is extinguiſht diſſipated, broken in pieces, or burnt out into aſhes. Fourthly, that it receives all its light from the Sun. Fifthly, that if the blaze were not made by the beams of the Sun paſſing through the head of the Comet, and ſo carrying the parts along with them, the blaze would not be oppoſite to the Sun. Sixthly, that the cauſe of the bending of the blaze is the refraction of the Suns raies in the body, and their being bent by the Æther as with a wind (which is the opinion that the Ingenious *Deſcartes* follows alſo.) To theſe I cannot conſent, and I have many objections to ſeveral other of his opinions concerning this matter, which would be too tedious to inſert; only I ſhall add, that having traced ſeveral of the Comets according to the beſt obſervations I could get, I found it very difficult to make their motion fall in a ſtraight line, unleſs it be granted that their motions are really accelerated and retarded in that line, which ſeems not ſo probable, at

leaſt not in thoſe parts of their tranſit where he places them. And particularly by tracing the way of this Comet of 1664. it is very evident that either the obſervations are falſe, or its appearances cannot be ſolved by that ſuppoſition, without ſuppoſing the way of it a little incurvated by the attractive power of the Sun, through whoſe ſyſtem it was paſſing, though it were not wholly ſtayed and circumflected into a Circle, as I have already mentioned.

That it is not extinguiſht or quite burnt out, when it ceaſes to appear, I argue from this, that I was able to ſee it with a Teleſcope above a month after it diſappeared to the naked Eye, as may be ſeen by the obſervations I have annext in *Fig.*4. and had not the cloudy weather and the light of the Moon, and nearneſs of the *Crepuſculum* hindred, I ſuppoſe I might have ſeen it much longer, as I am apt to believe the great one in 1618. might have been ſeen ſeveral months longer, if it had been diligently followed with Teleſcopes, it diſappearing in ſuch a part of the Heavens as might have been ſeen every clear night between the *Crepuſculum* and Dawning.

Nor can I ſuppoſe it to receive all its light from the Sun, ſince if ſo it would follow, that the *Nucleus* in the head, would have a dark ſhadow oppoſite to the Sun, the contrary of which has always been obſerved. Nor can I well underſtand that the Sun beams are like a ſtream of water, carrying the parts of the Comet along with them ſo as to make its blaze, ſince no ſuch effect is found of them here with us upon the Earth: Nor how they ſhould come to be bended like ſmoke, ſince we obſerve no ſuch property of light in a uniform medium, ſuch as in probability the Æther is.

Theſe were my thoughts about thoſe Comets which appeared in 1664. and 1665. which I have found in ſeveral looſe papers of Lectures, read in the beginning of 1665. And I have not had the opportunity of making many obſervations ſince, concerning Comets, ſave theſe two laſt, in which I had not

not the convenience of obſerving any thing certain concerning its motion or Parallax. And therefore I applyed my ſelf to mark as near as I could the true figure of it, through a ſix foot Teleſcope, and to take notice of as many circumſtances as the ſhort time I had would permit, which though they were very ſhort and tranſitory obſervations, and I wanted time to repeat them ſo often as I could have deſired, yet even from them I was ſufficiently ſatisfied, that I had reaſon to adhere to my former conjecture, that the light of the Comet did not depend wholly from the reflection of the Sun beams, from the parts thereof, but rather from its own light, for upon well conſidering of the form of this Comet, I manifeſtly ſaw that the middle of the blaze was brighter than the ſide parts thereof, and eſpecially that part which was immediatly oppoſite to the Sun, was the brighteſt of all, which would have been otherwiſe if the light had depended wholly from the deflection of the rays of the Sun, for one might rationally conclude that the *Nucleus* or Star in the middle, which reflected ſo great a quantity of light ſhould have cauſed a darkneſs in the parts behind it, as we ſee all ſtrong reflecting bodies do, and conſequently that the middle part of the ſtream or blaze, eſpecially that which was next the body ſhould not have been ſo bright as thoſe other parts to which the light of the Sun had a more free acceſs, unleſs it may be ſaid that even the Star it ſelf, though it ſeem ſo bright, is notwithſtanding not ſo Denſe, but that it admits rays enough to paſs through it unreflected, to inlighten the parts behind it. But this ſeems not ſo likely, ſince be the body of the Star ſuppoſed a thouſand times thinner than a Cloud (which yet tis hard to ſuppoſe, ſince it gives ſo conſiderable a reflection,) yet it being in all probability ten thouſand times bigger in bulk, the rays in paſſing through ſo great a bulk, muſt needs meet with more obſtruction than in the thinneſt Cloud, and yet we find that there is no Cloud ſo thin, but caſts

ſhadow oppoſite to the Sun, and therefore in probability this would do the like, but I diligently obſerved that there was no ſuch appearance here, but the contrary, that is, that where the ſhadow ſhould have been, there was the lighteſt part of all the blaze, and conſequently in probability it did depend upon ſome other cauſe than a reflection of light.

It is a hard matter to aſſign the particular cauſe of its light, but it ſeems from theſe circumſtances to be very probable that it was (in part at leaſt) from its own nature, whether that might be ſomewhat of that of the Sun and Stars, or of that of our fire, or of that of decaying fiſh, rotten wood, glow-worms, *&c.* or of that of the Ignis Fatuus, at Land or Sea, or like that of Sea-water, or a Diamond, or like that of the falling meteors, or Star-ſhoots, it will be very hard to determine, unleſs one had a much greater ſtock of obſervations to build upon. But it may poſſibly be ſomewhat of the nature of them all, though it agree not in all particulars with any one of them. All theſe ways that I have named ſeeming to agree in one particular, and that is an internal motion of the parts which ſhine, whether that motion be cauſed by ſome external menſtruum diſſolving it as in fire, and Ignes fatui, or an external motion, ſtroke, or impulſe as in a Diamond, Sea-water, and poſſibly ſome Ignes fatui, or from the parts of the bodies working and diſſolving one another, as in decaying fiſh, rotten wood, glow-worms, or whether it be ſuſceptible of a much more ſubtil impulſe, even from light it ſelf, as the *Bononian* ſtone, and *Bladwines* Phſophorus, which ſeems to be ſo harmonious (as I may ſo ſpeak) to the motion of light, that a new motion is thereby raiſed in it, and continues for ſome time to move of it ſelf after the impulſe or influence ceaſes, not much unlike the uniſon ſtring, or other ſounding body, which in Muſick receives a tremulation and ſound from the motion and ſound of the uniſon body, or ſtring that is ſtruck.

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To me It ſeems moſt probable that the body and parts of the Comet are in a ſtate of diſſolution, whether that diſſolution be cauſed by the parts of the Æther through which it paſſes, after the manner as a Torch is diſſolved by the air, or whether by the internal working of the conſtituent parts one upon the other, as in Gun-powder, ſhining Fiſh and rotten Wood, I cannot determine; but I rather gueſs it to be in ſome things analogous to the one, and ſomewhat to the other, though not exactly the ſame with either. And this I conceive from the figure and make of the ſhining parts, for if it had been of the ſame nature with a Torch, the blaze would have reſembled that of the flame of a Torch or Candle, that is, the ſides would have been brighter, and the middle darker, as I have ſhewn in my *Lampas*; whereas it was very manifeſt that the middle of the blaze was brighteſt, and of that blaze that which was next the Star or *Nucleus* was brighter than that which was further off: whereas in flame the contrary is very obſervable, as I have in the ſaid Treatiſe ſhewn.

From the ſhape of the figure, the manner of its diſſolution ſeems to be thus. The Star or *Nucleus* in the middle, ſeems to be the *fomes* or ſource from whence all the light proceeds: this we ſuppoſe to be a denſe body encompaſt with a very fluid body (ſuch as the Æther ſeems to be) but of ſuch a looſe and ſpongy nature, as that the Æther doth cauſe thoſe parts which are contiguous to it, to be diſſolved and expanded into it ſelf. This diſſolution and expanſion I conceive doth generate or cauſe the light that ſeems to proceed from it, that diſſolution cauſing ſuch a motion of the Æther, as is neceſſary to produce the appearance of light; now ſo long as any part thereof remains in diſſolution, ſo long doth it continue to ſhine, as is alſo obſervable in the flame of any body burning in the air, but when the part ſeparated from the body is quite diſſolved into the Æther, the effect of ſhining ceaſes, as it doth

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alſo in the parts of flame. Now I have obſerved that the blaze is ſo very much rarified, that firſt the Æther I conceive comes very freely to every particle of the body after it is ſeparated from it, but eſpecially to the outermoſt, and continues to be incompaſſed with it ſo long as till it be quite diſſolved into it, which I conceive to be at a little farther diſtance from the head than the greateſt length of the blaze ſeems to be to our ſight. And further I conceive that the outward parts being thus incompaſſed more perfectly with the free and undiſturbed Æther, are ſooner diſſolved into it than thoſe of the middle, and conſequently the ſides ſeem firſt to diſappear, and the middle parts continue their ſhining to a much greater diſtance from the Star in the head, though ſomewhat alſo of that appearance may be aſcribed to the diſperſing and rarity of the parts near the ſides.

The *Nucleus* or Ball in the middle of the head, which I have called the Star, I conceive to be diſſolved equally on all ſides, and the parts which are diſſolved or ſeparated from it, I conceive to fly every way from the center of it, with pretty near equal celerity or power, like ſo many blazing Granadoes or Fire-balls, theſe continue their motion ſo far toward the way they are ſhot, till the Levitation from the body of the Sun deflect them upwards, or in oppoſition to the Sun into a Parabolick curve, in which Parabolick curve, every ſingle particle continues its motion till it be wholly burnt out, or diſſolved into the Æther. Theſe are continually ſucceeded by new ſeparations from the aforeſaid body in the ſame manner as tis obſervable in a burning, ſteaming, or ſmoaking body in our air, or a diſſolving body incompaſſed with its proper menſtruum, as I before mentioned, and will ſo continue until the whole be at length diſſolved into the Æther, through which it paſſes.

It hath been demonſtrated by *Torricellius*, of bullets or other bodies caſt or ſhot upwards, that the ſame

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or equal bullets diſcharged or ſhot out from the ſame point, with the ſame degree of ſtrength, but with differing degrees of inclination to the Horizon, each of them ſhall be moved in a parabolical line, and every one of thoſe parabolical lines ſhall touch a parabolical line, whoſe axis is the perpendicular, and whoſe apex is diſtant from the ſaid point, the full altitude of the perpendicular ſhot: So that ſuppoſing in the twenty ſecond figure, A to be the point from whence all the ſhots are made with equal velocity, A C the greateſt height of the perpendicular ſhot, and A D the greateſt Horizontal random at 45 degrees of inclination, and ſuppoſe E D C D E a parabola paſſing through thoſe points D C D, all the ſhots made with equal bullets, with equal velocity from A, but with all variety of inclination between the perpendicular upwards, and the perpendicular downwards that touch the ſaid parabolical line, and conſequently if there be an indefinite number of ſuch balls continually flowing out of the point A, with equal degrees of celerity every way diſperſing themſelves equally *in orbem*, the whole aggregate of ſuch an emanation will make a ſolid parabolical conoeid E D C D E. Now about the point A, if we ſuppoſe a Sphere as B B B B, and from this Sphere an indefinite number of ſuch equal Balls be thrown off perpendicularly to the ſuperficies of it, from every point thereof, with equal celerity at their leaving it, thoſe emanations will form alſo a conoeid, which will be very near the ſame with the former: And if this Ball in the middle be ſuppoſed a burning and ſhining body, and that all theſe emanations have every one of them equal light in proportion to the Globe B B B B A, the effect produced hereby will perfectly reſemble the appearance and figure of Comets, if at leaſt the Parabolical conoeid be inverted; which will ſomewhat explain the manner how I conceive the figure of the Cometical body is naturally, and moſt proportionably formed; for if the effect of

alſo in the parts of flame. Now I have obſerved that the blaze is ſo very much rarified, that firſt the Æther I conceive comes very freely to every particle of the body after it is ſeparated from it, but eſpecially to the outermoſt, and continues to be incompaſſed with it ſo long as till it be quite diſſolved into it, which I conceive to be at a little farther diſtance from the head than the greateſt length of the blaze ſeems to be to our ſight. And further I conceive that the outward parts being thus incompaſſed more perfectly with the free and undiſturbed Æther, are ſooner diſſolved into it than thoſe of the middle, and conſequently the ſides ſeem firſt to diſappear, and the middle parts continue their ſhining to a much greater diſtance from the Star in the head, though ſomewhat alſo of that appearance may be aſcribed to the diſperſing and rarity of the parts near the ſides.

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ſuch an emanation of ſhining bodies be examined, it will very plainly exhibit the exact and true apparent figure of Comets, as they may be ſeen through a good Teleſcope, which is to me a very great argument, that 'tis the genuine cauſe of its ſhape and figure: Now though the Comets appearance be this way cauſed, and ſo a man might conceive the Globous body would in a little time (by ſo copious an emanation) be conſumed, yet I do not believe that it doth in a ſhort time waſt and diſperſe the whole Ball, nor can I conceive that the diſappearing of thoſe blazing bodies toward the latter end, does depend upon their diſſolution (though poſſibly that may ſomewhat diminiſh them) but that rather is to be aſcribed to their diſtance and poſition in reſpect of us: Though this I remember I obſerved very manifeſtly in that of 1664. that the body toward the latter end of its appearing was very much leſs in proportion to the radiations about it, than it ſeemed to be at the beginning, but whether that might not be partly aſcribed to the great diſtance it then was from us, and the turning of the head pretty near towards us, and thence the ſpreading of the Tail (appearing beyond it,) might add to the breadth of the radiation about the *Nucleus*, I will not poſitively determine. Now though for explication ſake, I have compared the parts ſeparated from the body of the Comet to blazing Granadoes or Fire-balls, yet I would not be underſtood to ſuppoſe theſe parts ſo ſeparated to be of any very large bulk, for I ſee no neceſſity to ſuppoſe them bigger than the Atoms of ſmoke, or the particles of any other ſteaming body, or than the parts of the Air, which make the body of it appear thick and hazy; nor do I believe that all the light of the Star, head, and blaze, does depend only upon the ſhining of the diſſolving body and particles thereof: but I do ſuppoſe that it doth proceed both from the reflection of the Sun-beams from thoſe parts, and alſo from an innate and momentaneous light produced by the

the action of diſſolution wrought on the parts by the incompaſſing Æther.

It may poſſibly ſeem very difficult to ſuppoſe that the diſſolution of the parts of the *Nucleus*, by the incompaſſing Æther, ſhould cauſe or impreſs ſo violent a motion into the ſeparated parts, as to make them depart from it to the ſpace of four or five Diameters, before it be over-powered by the power of Levitation from the body of the Sun, and ſo deflected into a parabolical line upwards. It may likewiſe ſeem ſtrange to ſuppoſe that the Æther ſhould have ſuch power in it, as firſt to diſſolve a body into it ſelf, and ſecondly to cauſe a ſhining, and thirdly to cauſe a Levitation of the diſſolved parts upwards; whereas I ſuppoſed before (and I think 'tis very manifeſt) that they cauſe a gravitation downwards, towards the Center of the Sun: But to theſe for explication, I anſwer that we need not go far for inſtances to make theſe things probable, the Atmoſphere about the Earth, as I have formerly mentioned in my *Micrographia*, I take to be nothing elſe but the diſſolution of the parts of the Earth into the incompaſſing Æther; for the proof of which, I could bring many arguments, were it here a proper place, by which I could moſt evidently demonſtrate the thing to be as I have aſſerted. It is here evident that this Æther doth take up the particles of bodies to a very great diſtance from the ſurface from which they were ſeparated, and it doth not only raiſe them but ſuſteins them at thoſe heights, nor is this peculiar only to the Æther when a menſtruum, but to all diſſolving menſtruums in general.

As to give one inſtance, in ſtead of many, we find that Gold (the heavieſt of all Terreſtrial bodies we yet know,) being diſſolved by *Aqua Regis*, is taken up into it, and kept ſuſpended therein, though the parts of the Gold be fifteen times heavier than the parts of the *Aqua Regis*. So Pit-coal though very heavy, is yet taken up into the Air, and kept ſuſpended there-

in, though it will be found to be ſome thouſands of times more ponderous than the menſtruum of the Air that keeps it ſuſpended.

Many reaſons I could produce to ſhew the great power of the Æther, and the univerſality of its activity almoſt in all ſenſible motions, but reſerving them for another Diſcourſe hereafter, I ſhall at preſent, only mention thoſe ſuppoſitions which ſeem to have the greateſt difficulty, in this Theory, *viz.* how the diſſolution of the parts of the Star by the incompaſſing Æther ſhould cauſe light, and ſecondly how it ſhould cauſe an actual Levitation of the diſſolving particles upwards. For the explication of theſe two difficulties, I muſt at preſent crave favour to explain them by examples taken from operations of Nature in the Atmoſphere wherein we live, very ſimilar and analogous to them. Firſt, for the production of light, we find that the Air incompaſſing the ſteams of bodies prepared by heat or otherwiſe, and made fit for diſſolution, doth ſo operate upon them, as to make them fly and part aſunder with a very impetuous motion, inſomuch that the ſmall particles or Atoms of the diſſolved bodies, do not only leave one another, but depart and dart out with ſo great an impetuoſity, as to drive off all the incompaſſing Air from their Center from whence they flew, and this I take to be the cauſe not only of their Light, but alſo of their Levity upwards, this may be ſeen very plainly by the ſmall parts of crackling Char-coal, which upon the blowing them with Bellows, and ſo crowding a great quantity of the freſh menſtruum on them, fly and dart aſunder with great celerity and noiſe, but is abundantly more evident in the kindling of Gun-powder, where the impetuoſity is ſo very great as to drive away not only all the incompaſſing Air but all other bodies, though never ſo ſolid, that hinder its expanſion, in the performing of which operation the Æther hath a great ſhare, as I may hereafter ſhew, 'tis very probable that the

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Æther in the ſame manner diſſolving the particles of the Star, cauſeth the Atoms thereof to fly aſunder with ſo great an impetuoſity as to leave a vacuity even of the parts of the Æther, which flying aſunder doth not only cauſe light by impreſſing on the Æther a ſtroke or pulſe which propagates every way *in Orbem*, but maketh ſuch an agitation of the the Æther, as cauſes a rarefaction in the parts thereof, whilſt the parts that are once actually ſeparated, by continual rebounding one againſt another before they come to be at reſt and quietly to touch each other, prolong that firſt ſeparation or vacuity between them.

This Explication, though it be ſomewhat difficult, yet I hope it is intelligible, and may be, with probability enough, ſuppoſed to be the true cauſe of the appearance, whilſt there is nothing therein ſuppoſed which is not manifeſtly the method of Nature in other operations; and though the ſuppoſition even of the Æther, may ſeem to be a Chimera and groundleſs; yet had I now time, I could by many very ſenſible and undeniable experiments, prove the exiſtence and reality thereof, and that it doth actually produce not only as ſenſible effects as theſe I have named, but very much the ſame, and many others much more coſiderable, which by Philoſophers have hitherto been aſcribed to quite different cauſes.

Had I been able to have made ſome other obſervations (which I deſigned, if I had had the opportunity of ſeeing it, ſome of the ſucceeding Nights,) I ſhould have hoped to have explained ſeveral other difficulties concerning the nature of the body and blaze of Comets, but being therein prevented, I muſt leave them till I can make ſome further obſervations on ſome Comets that may hereafter appear.

In the mean time that what I have diſcourſed concerning the light of Comets, may not ſeem ſo altogether paradoxical and unintelligible as ſome may ima-

gine, I have here added an account of ſome trials and obſervations made on ſhining ſubſtances of natures exceedingly differing from thoſe that are commonly to be met withal. And this I the rather do, not only becauſe it affords an inſtance of ſhining where there is no Air, but that hereby I may enlarge the limits of their imagination, who ſhall conſider of this ſubject. For nothing is more apt to miſguide our reaſoning than a narrow and limited knowledg of cauſes, we are not to conclude the body of a Comet a ſulphureous vapour exhaled from the Earth and kindled above, becauſe here are ſuch vapours obſerved and ſuch effects produced, nor a collection of Sun beams made by a Lentiformed vapour, after the manner of a Burning-glaſs (as ſome eminent Writers have lately done,) becauſe ſome ſuch appearances may be Artificially produced in a ſmoaky or thickned Air; ſince if we diligently inquire, we may find that light which is the moſt ſenſible quality of Comets that affects our ſenſes, may be, and really is produced by very many, and thoſe very differing ways. In Nitre and Sulphur kindling each other by heat, we have one way; in a body burning in the Air a ſecond, in a heated Iron or Glaſs a third, in a piece of Iron hammered till red hot a fourth, in rotten Wood and decayed Fiſh a fifth, in Glow-worms, *Scolopondras*, and other living Worms, and in the ſweat and excrements of other living creatures a ſixth, in a Diamond rubbed a ſeventh, in Dews Ignes fatui, *&c.* an eighth, in Sea-water a ninth, in the *Bononian* ſtone, and in the Phoſphorus *Baldwini* (which I take to be much of the ſame nature) a tenth, in the Phoſphorus of Mr. *Kraft* an eleventh, and poſſibly wholly differing from all theſe, may be the light of the Sun, a twelfth, and that of the Star may differ from that of Sun, and the Comet may be differing from all the reſt. Whether they be ſo or not, the being acquainted with the ſeveral proprieties of them will the better enable one to judg of what is pertinent

nent to be obſerved in Comets, in order to find out which is concerned.

The Phænomena of moſt of theſe ſhining bodies are very common and obvious, and therefore needleſs to be added; but that of the *Bononian* ſtone prepared, and that of the *Phoſphorus Baldwini* (lately diſcovered by Mr. *Baldwine*) are rare and hard to be got, and the effects of them are wholly differing from all the ways I have yet met with, and will therefore prove *Experimenta Crucis*, highly inſtructive in the Theory of Light, of which more hereafter. As for the *Phoſphoros Fulgurans* of Mr. *Kraft* (more ſcarce and rare than the other) 'tis wholly differing from any of the reſt, and very ſtrange and ſurpriſing, at leaſt it appeared ſo to me, who had the good fortune to be preſent at a good part of the experiments made by the Author in the preſence and at the Chamber of the Honourable *Robert Boyle*, Eſq; that great Judg and Promoter of all curious inquiries into Nature and Art, who at my earneſt intreaty, was not only pleaſed to commit to writing what he obſerved, but (for the information of Curious and Inquiſitive Naturaliſts,) to give me liberty here to publiſh it.

A ſhort Memorial of ſome Obſervations made upon an Artificial Subſtance, that ſhines without any precedent Illuſtration.

September, 1677.

ON *Saturday* the fifteenth of this month I was after ſupper viſited by Mr. *Kraft*, a famous *German* Chymiſt, who was pleaſed to come and ſhew me a ſtrange rarity he hath newly brought into *England*, to the ſight whereof he allowed me to invite ſeveral members of the Royal Society, he being deſirous, becauſe the matter he imploys is very coſtly and of difficult preparation, to be a good Husband of it, and by ſhewing it to ſeveral curious perſons at once, to exempt himſelf from the need of ſhowing it often. The Company being met, the Artiſt took out of a pretty large box he had brought with him, divers Glaſs Veſſels and laid them in order on the Table. The largeſt of them was a Sphere of Glaſs, which I gueſſed to be four or five Inches in Diameter, being hollow and intire, ſave that in one place there was a little hole, at that time ſtopt with ſealing wax, whereat to pour in the Liquor, which ſeemed to me to be about two Spoonfuls or ſomewhat more, and to look like muddy water made a little reddiſh with brick-duſt or ſome other powder of that colour, he alſo took out of his Box three or four little pipes of Glaſs ſealed, or o-

therwiſe ſtopt at both ends, being each of them ſomewhat bigger than a Swans quill, and about five or ſix Inches long, and having at one end a ſmall fragment or two of that matter that was to ſhine in the dark.

He likewiſe laid upon the Table three or four Vials of ſeveral ſizes, but none of them judged capable to hold above very few Ounces of water: in each of which Vials there was ſome Liquor or other, that was neither tranſparent nor well coloured, which Liquors I confeſs upon his making no particular mention of what they were to do, I was not curious to compare together, either as to quantity or as to colour. Beſides all theſe ſubſtances which were fluid, he had in a ſmall Cryſtalline button Bottle, a little lump of matter, of which he ſeemed to make much more account than of all the Liquors, and which he took out for a few moments to let us look upon it, whereby I ſaw that it was a conſiſtent body, that appeared of a whitiſh colour, and ſeemed not to exceed a couple of ordinary Peaſe, or the kernel of a Haſel Nut in bigneſs, ſome other things 'tis poſſible Mr. *Kraft* took out of his Box, but neither I or (for ought I know) others of the Company took notice of them, partly becauſe of his haſt, and partly becauſe the confuſed curioſity of many ſpectators in a narrow compaſs, kept me from being able to obſerve things as particularly and deliberately as I would gladly have done, and as the occaſion deſerved. Which Advertiſement may I fear be but too applicable to a great part of the following Narrative.

The forementioned Glaſſes being laid in order upon the Table, the windows were cloſed with woodenſhuts, and the Candles were removed into another Room by that we were in; being left in the dark we were entertained with the enſuing Phænomena.

I. Though I noted above that the hollow Sphere of Glaſs had in it but about two Spoonfuls (or three at moſt) of matter, yet the whole Sphere was illuminated by it, ſo that it ſeemed to be not unlike a Cannon bullet taken red hot out of the fire, except that the light of our Sphere lookt ſomewhat more pale and faint. But when I took the liberty to hold this Glaſs in my hand and ſhake it a little, the contained Liquor appeared to ſhine more vividly, and ſometimes as it were to flaſh.

II. I took one of the little pipes of Glaſs formerly mentioned, into my hand, and obſerved that though the ſhining matter had been lodged but at one end, yet the whole Glaſs was enlightened, ſo that it appeared a luminous Cylinder, whoſe light yet I did not judg to be always uniform, nor did it laſt like that which was included in the Vials.

III. In the largeſt of the Vials next the Spherical already mentioned, the Liquor that lay in the bottom being ſhaken, I obſerved a kind of ſmoke to aſcend and almoſt to fill the cavity of the Vial, and near the ſame time there manifeſtly appeared as it were a flaſh of lightning that was conſiderably diffuſed, and pleaſingly ſurprized me.

IV. After this I took up that ſmall Cryſtaline Vial that I lately called (by a name familiar in our Glaſs-ſhops) a Button-Bottle, wherein was contained the dry ſubſtance which the Artiſt chiefly valued, as that which had continued luminous about theſe two years, and having held that Vial long in my hand, in the ſame poſition in reference to my eye, and lookt attentively at it, I had the opportunity to obſerve (what I think none of the Company did) that not only this ſtuff did in proportion to its bulk, ſhine more vividly than the fluid ſubſtances, but thaat which was the Phænomenon I chiefly attended) though I could perceive no ſmoke or fumes aſcend from the luminous matter, yet I

could plainly perceive by a new and brisker light that appeared from time to time in a certain place near the top of the Glaſs, that there muſt be ſome kind of flaſhy motion in the matter that lay at the bottom, which was the cauſe of theſe little coruſcations, if I may ſo call them.

V. The Artiſt having taken a very little of his conſiſtent matter, and broken it into parts ſo minute, that I judged the fragments to be between twenty and thirty, he ſcattered them without any order about the Carpet, where it was very delightful to ſee how vividly they ſhined; and that which made the ſpectacle more taking, eſpecially to me, was this, that not only in the darkneſs that invironed them, they ſeemed like fixt Stars of the ſixth or leaſt magnitude, but twinkled alſo like them, diſcovering ſuch a ſcintillation as that whereby we diſtinguiſh the fixt Stars from moſt of the Planets. And theſe twinkling ſparks without doing any harm (that we took notice of) to the Turky Carpet they lay on, continued to ſhine for a good while, ſome of them remaining yet vivid enough till the Candles being brought in again made them diſappear.

VI. Mr. *Kraft* alſo calling for a ſheet of Paper and taking ſome of his ſtuff upon the tip of his finger, writ in large Characters two or three words, whereof one being *DOMINI*, was made up of Capital Letters, which being large enough to reach from one ſide of the page to the other, and being (at leaſt as I gueſſed) invigorated by the free contact of the external Air, ſhone ſo briskly and lookt ſo oddly, that the ſight was extreamly pleaſing, having in it a mixture of ſtrangeneſs, beauty and frightfulneſs, wherein yet the laſt of thoſe qualities was far from being predominant. And this Phænomenon did in more ſenſes than one afford us the moſt of light, ſince not only the Characters ſhone very vividly upon the white Paper, but approaching it to my Eyes and Noſtrils, I could diſcern

diſcern that there aſcended from them a fume, and could ſmell that fume to be ſtrong enough, and (as it ſeemed to me) to participate of the odour of Sulphur and of that of Onions. And before I paſt from the mention of theſe reſplendent Characters, I muſt not forget that either by their light, or that of the Globe, or both by the one and the other a man might diſcern thoſe of his fingers that were neareſt the ſhining ſtuff, and that this being held to the face though without touching it, ſome of the conſpicuouſeſt parts, eſpecially the Noſe, were diſcoverable.

VII. After we had ſeen with pleaſure, and not without ſome wonder, the fore-going particulars, the Artiſt deſired me to give him my hand, which when I had done, he rub'd partly upon the back of it, and partly on my cuff, ſome of his luminous matter, which as if it had been aſſiſted by the warmth of my hand ſhone very vividly, and though I took not notice of any thing upon my skin, that was either unctuous or rough, yet I often times tried in vain by rubbing it with my other hand to take it off, or manifeſtly diminiſh its ſplendor, and when I divers times blow'd upon ſome of the ſmaller parts of it, though they ſeemed at the inſtant that my breath beat upon it, to be blown out, yet the tenacious parts were not really extinguiſht, but preſently after recovered their former ſplendor. And all this while this light that was ſo permanent, was yet ſo mild and innocent that in that part of my hand where it was largely enough ſpread, I felt no ſenſible heat produced by it.

By that time theſe things were done 'twas grown late, which made Mr. *Kraft*, who had a great way to go home, take leave of the Company after he had received our deſerved thanks for the new and inſtructive Phænomena, wherewith he had ſo delightfully entertained us.

Becauſe Mr. *Kraft* had twice attempted to fire heated Gun-powder with his Phoſphorus, but without ſucceſs; probably becauſe the powder was not very good (as by ſome circumſtances I conjected) and becauſe it was not ſufficiently heated before the matter that ſhould ſet it on fire was put upon it, he promiſed me he would come another time to repair that unſuccesfulneſs: And accordingly, On the two and twentieth of *September* in the Afternoon I recived a viſit from Mr. *Kraft*, who told me he came to make good his promiſe of letting me ſee that his ſhining matter was able to kindle heated Gun-powder, and becauſe no ſtrangers were preſent, I had the fairer opportunity to view it, which I was able to do better by day light, than I had done by its own light, for when he had taken it with a new Pen out of the liquor with which he kept it covered to preſerve it, I perceived it to be ſomewhat leſs than the nail of one of my fingers, and not much thicker than a ſhilling, and I obſerved that when it had lain a little while upon a piece of clean Paper and diſcharged it ſelf from its ſuperfluous moiſture, it began to emit whitiſh fumes which ſeemed to be very ponderous, ſince for the moſt part they did not aſcend but ſurrounding the matter whence they iſſued, by their ſtagnation made as it were a little Pond or ſmall Atmoſphere about it; ſo that leſt it ſhould waſt too faſt, he was obliged as ſoon as he had cut off a little corner leſs than half a pins head, to put the ſtuff nimbly back into the Vial out of which he he had taken it; where I obſerved it for a very ſhort time to ſend up exhalations into the liquor that covered it, and quickly after, as it were, quencht it. This done the Artiſt divided the little corner he had cut off into two parts, one of which he ſpread as far as it would reach upon a piece of white Paper, which he preſently after held at a diſtance over a chafing-diſh of burning Coals, by whoſe heat being excited it preſently flaſht and burnt away, and I having perceived that there was another part of the

Paper

Paper which though not heeded by him, had been lightly beſmeared by the ſame matter, I held it over the Coals, but at a conſiderable diſtance from them, and yet this little matter nimbly took fire and burnt a hole in the Paper. And to ſatisfie my ſelf that the heat did but excite the luminous matter, and that twas this its ſelf that lighted the Paper, I held the reſt of the ſame piece of Paper far nearer the fire and kept it there a pretty while without finding it at all ſcorched or diſcoloured. Laſtly, the other part of the divided fragment of the hitherto mentioned matter, Mr. *Kraft* put upon the tip of a quil, and having at a diſtance from the fire, very well dryed and warmed ſome Gun-powder upon another piece of Paper, he laid that Paper upon the ground, and then holding his quill upon it, as if it had been a match, within half a minute (by my gueſs) that powder took fire and blew up.

'Twill not perhaps be impertinent to add that on occaſion of the operation I obſerved the Air to have on the ſhining ſubſtance when freely expoſed to it. I took a riſe to tell Mr. *Kraft* that I preſumed it might be worth while to try whether his Phoſphorus did ſhine by virtue of a kind of real or (if I may ſo call it) living flame, which like almoſt all other flames required the preſence and concourſe of the Air to maintain it, or whether it were of ſuch a kind of nature as the Phoſphorus of the learned *Baldwinus*, which I ſuſpected to ſhine not like a flame or a truly kindled ſubſtance; but like a red hot Iron, or an ignited piece of Glaſs, wherein the ſhining parts are not repaired by fewel, as in other burning bodies, but are put by the action of the fire into ſo vehement an agitation as whilſt it laſts ſuffices to make the body appear luminous. This conjecture Mr. *Kraft* ſeemed much to approve of when I told him that the way I propoſed to examine his *noctiluca* by, was to put a little of it into our Pneumatick Engine, and Pump out the Air, whoſe abſence

abſence, if it were of the nature of other flames, would probably extinguiſh, or very much impair its light, but yet ſince he offered not to have the trial made; probably becauſe he had but very little of his ſhining ſubſtance left, I thought it not civil to preſs him. But to countenance what I ſaid of the nature of *Baldwinus Phoſphorus*, I ſhall recite an Experiment that I purpoſely made, to examin whether the preſence of the Air were neceſſary to the ſhining of this Phoſphorus, as I had long ſince found it to that of ſome pieces of ſhining wood.

We expoſed for a competent time to the beams of a vigorous light, a portion of matter of about the breadth of the palm of ones hand, which we had prepared to be made luminous by them. And then cauſing the Candles to be removed (for we choſe to make tryal by night) we nimbly conveyed the matter into a receiver that was kept in readineſs for it, preſuming (as the event ſhewed we might) that by uſing diligence the light would laſt as long as the experiment would need to do; making haſt therefore to Pump out the Air, we heedfully watched whether the withdrawing of it would, contrary to my conjecture, notably diminiſh the light of the ſhining matter. And after we had thus withdrawn the Air gradually, we tryed whether by letting it return haſtily, it would produce a more ſenſible change in the matter (which had been purpoſely put in without any thing to cover it, that it might be the more expoſed to the Airs Action.) But neither upon the gradual receſs of the Air, nor yet upon its ruſhing in when it was permitted to return, could we certainly obſerve any manifeſt alteration in the luminouſneſs of the Phoſphorus, other than that ſlow decrement that might well be imputed to the time during which the experiment was making. It being well known that this luminous ſubſtance requires no long time to make it decay, and by degrees to loſe all its light; ſo that though once there ſeemed to one

or

or two of the by-ſtanders, upon the return of the Air, to be ſome recovery of part of the loſt ſplendor, yet after repeated experiments it was concluded that the preſence of the Air was not at all *neceſſary* to the ſhining of our matter, and it was judged moſt probable that the abſence or preſence of the Air, had *no manifeſt* operation on it. I might add to this that perhaps the preſence of the Air is rather hurtful than advantagious to this ſort of lights, ſince for having had a large Phoſphorus that was much eſteemed, and, whilſt I kept it, exactly protected from the Air did very well; a part of the Glaſs that covered it, having by miſchance been ſomewhat crackt, though none of the ſplinters appeared diſplaced, yet it ſeems ſome of the Corpuſcles of the Air made a ſhift to inſinuate themſelves at theſe chinks (as narrow as they were) and in not many days made the matter ceaſe to be capable of being made luminous as before. I cannot ſtay to inquire whether this unfitneſs or indiſpoſition may be imputed to the bare moiſture of the Air, or to ſome other ſubſtance or quality that alone or in conjunction with the moiſture, may ſpoil that peculiar texture, or conſtitution that fits the matter of the Phoſphorus aſſiſted by the impreſſions of external light to become luminous. This, I ſay, I cannot ſtay to examine, though, That this Phoſphorus is of a nice and tender conſtitution, and eaſily alterable, I was induced to think, by finding that the want of circumſtances, ſeemingly ſlight enough, would keep it from being made; and I gueſs that a convention of circumſtances did more contribute to the production than any peculiar and incommunicable nature of the matter: Becauſe having had the curioſity to make ſome trial upon ſo obvious a material as quick Lime, though the ſucceſs did not anſwer my deſigns, yet, neither was it ſo bad, but that ſome luminous quality was produced in the Lime by the action of the fire, and a ſaline Liquor; and I ſcarce queſtion but other materials will be found

capable of being made luminous by the ſame or the like operation, that is imploy'd by *Baldwinus*, when that learned man ſhall think fit to communicate his way to the Publick. But to return to what I was ſaying, that the contact of the Air might be rather hurtful than advantagious to the Phoſphorus, I ſhall only add here as matter of fact, (for my conjectures about Light belong to my yet unpubliſht Notes, *of the Origine of Qualities*) that whereas the contact of the Air, though it were not free, did in a few days deſtroy the luminouſneſs of a good Phoſphorus, yet having included another in a Receiver, whence we afterwards pumpt out the Air, this matter though inferior to the other in vividneſs was ſo little ſpoiled by lying open in our Vacuum, that at the end of not only ſome weeks, but ſome months, I found that the beams of a Candle paſſing to it through the Receiver, would notwithſtanding the Vacuum it yet continues in, ſuffice to re-excite in it a manifeſt light.

Thus far was the communication of this excellent perſon, who it's hoped may be further prevailed with to communicate thoſe other accurate obſervations, and curious reſearches he hath made concerning the light of the *Bononian* Stone, and the *Phoſphoros Baldwini*, which are indeed truly admirable, and very much differing from the uſual proceſſes of Nature for the exhibiting of light.

Before I take leave of my Aſtronomical Readers, I ſhall here acquaint them with ſome Collections I have made of other Aſtronomical matters and diſcoveries, which I hope will not be leſs pleaſing to them than they were at firſt to me. The Diſcoveries are new, and not leſs ſignificant. The firſt is,

A Let-

A Letter from Johannes Carolus Gallet, *L.L.D. and Provoſt of the Church of St.* Symphorean *at* Avignon, *directed thus.*

CLariſſimo Eruditiſſimoque viro D. Johanni Dominico Caſſino, Matheſeos Profeſſori Celeberrimo, Aſtronomo præſtantiſſimo & Academiæ Regiæ ſcientiarum alumno meritiſſimo.

Conteining an account of his obſervation of Mercury paſſing under the Sun.

Mr. *Gallet* then acquaints Mr. *Caſſini* with his obſervation of ☿ *ſub* ☉ and the whole method and proceſs of his obſervation. Firſt, he fitted two excellent Teleſcopes, the Glaſſes of which were given him by Mr. *Jac. Borrellius*, one of the Academy Royal of *Paris*. The one of twenty three foot, he fitted with a Glaſs covered with ſmooke, placed in the outward *focus* of the Eye-Glaſs: The other of three foot he fixt to the Arm of his Quadrant of the ſame Radius, this was ſo exquiſite that compared with one of *Divini*, which was choſen by the care of *Honorato Fabri*, and procured by Monſieur *de Beauchamps*, it was found to repreſent the objects clearer: By this the figure of the Sun was caſt on an oppoſite Table, on which he had drawn a Circle of the bigneſs proper to the Diſtance and Magnifying of the Glaſſes to contain the whole Face of the Sun, and by Parallel Circles had ſubdivided the ſame into digits and Sexageſimals, he had alſo placed three threds in the interior *focus* of the Glaſſes, that the middlemoſt went through the Center, and the two outward touched the Limb of the Sun by their ſhadow on the Table, he had alſo a Pendulum Clock that vibrated thrice in a ſecond. Thus accoutred he watched the fifth

and ſixth day, from Sun riſing to Sun ſetting, and the ſeventh after the Cloudy Sky had ſeemed to delude his curioſity till Eleven a Clock almoſt, it then began to open and diſcovered to him Mercury got within the Eaſtern Limb of the Sun, about $\frac{1}{6}$ of its Semidiameter; at length the Clouds being diſperſed, the Sun being 27° 45. high, or at 10 h. 54′ ☿ it ſelf marked out its own place in the disk of the ☉ by its own ſhadow caſt on the Table by the ſhorter tube. Then he diſpoſed the ſhadow of the aforeſaid thred ſo Paralel to the Equator, that this figure of the Sun ſhould move between the outward ones, and that the middle ſhould mark out the Paralel deſcribed by the Center of the Sun in motion, at the ſame time he took the declination of ☿ from this middle Parallel and the right Aſcention, by the number of Vibrations of the Pendulum, from the Weſtern Limb of the Sun, taken by the ſhadow of a Perpendicular Croſs-line to the other 3. by the ſame means, alſo he meaſured the Diameter of the Sun and of Mercury.

Then to the end he might give leſs cauſe of doubt, according to his uſual cuſtom, he procured ſeveral friends who were preſent and witneſſes of all the obſervations after the fourth mentioned in the Table. During the obſervation he took notice of theſe remarkable accidents. Firſt, that Mercury through the long Tube was very black, and of an Elliptical figure whoſe longeſt Diameter was Parallel to the Equator, but in the Species through the leſſer Telecope, it appeared round and of a dusky red (like a ſpot obſerved by him in the Sun from the Ninth to the Fifteenth of *April.*) Secondly, that the Diameter of Mercury going out of the Diſc of the Sun, when it toucht the periphery ſeemed to be of four times the Diameter it appeared of through the whole Phaſe, ſo that Mr. *Beauchamp*, who watched the exit with the longer Tube, whilſt he himſelf minded the Quadrant in order to take the Altitude of the Sun, at the time of the exit cried out, O how large do

I ſee

I ſee the Diameter of Mercury now, it does not only leave the Sun, but is confuſed with it, or as it were melts into it, and preſently it vaniſht, the Sun being then 13. 23′. high.

He further adds that before he leaves to ſpeak of the Sun, he will here inſert an obſervation that he had made of four ſpots he had ſeen in the Sun in the firſt of *October* laſt (*St. No.*) with this his longer Teleſcope, one only of which was viſible by the Species caſt with the leſſer Glaſs.

Octob. Die.	hora		*Declinat. maculæ principalis à paral. Centri* ☉.			*Differentia temp. inter limbum* ☉ *Occident. & maculam.*			*Tempus tranſitus diſci Solaris.*		
1	10	0	4	44	*auſtr.*	1	4	20	2	10	0
2	10	0	2	43	*auſt.*		49	0	2	10	20
3	10	30	1	21	*auſt.*		35	40	2	10	20
4	10	35	0	40	*auſt.*		25	40	2	10	30
6	10	0	3	0	*boreal.*		3	20	2	10	4

Thus ſubmitting his method to the judgment of the Learned *Caſſini*, and earneſtly deſiring his thoughts thereon, he ends his Letter, and Dates it from *Avignon*, *Nov.* 21. 1677.

To this Letter he ſubjoins the obſervation it ſelf, Intituled,

Mercurius ſub Sole viſus Avenione *die* 7. Novemb. 1677. *Obſervante me* Joanne Carolo Gallet, *J. V. D. Præpoſito Eccleſiæ Sancti Symphoriani* Avenionenſis.

The Contents of which are,

That deſigning to obſerve this paſſage of ☿ under ☉ he with his Tube watchfully looked for it in the Suns place, from the 5th to the 7th. day, with a Teleſcope of

23 foot (as above) he obſerved a ſpot of an elliptical figure which had already gotten a 16th. part of the ſemidiameter of the Sun within the limb, and declined a little to the South in reſpect of the parallel of the Æquator drawn through the Suns center, at 10 hours 26 min. but the Clouds hindering he could not obſerve its motion till it had aſcended as high as the parallel: when the Suns altitude was 27. 45. or 10 a Clock 54 minutes. From the quickneſs of its motion he ſoon found it to be ☿ and not a ſpot, and therefore he forſook not his Quadrant to which was fitted his three foot Teleſcope and Table to receive the figure of the ☉ but obſerved the times of the Immerſions and the Emerſion of ☿ by the help thereof, being aſſiſted by ſeveral of his friends who were witneſſes of what paſſed, and particularly by the Illuſtrious Monſieur *De Beauchamp*, who with the twenty three foot Glaſs determined the Exit of *Mercury*, whileſt he himſelf took the Altitude of the Sun with his Quadrant, as in the tenth Obſervation.

The Order of the Obſervations of Mercury ſeen under the Sun.

The number of the Phaſes obſerved.	The north Declination of ☿ from the Parallel of the equat. through the Center.		The difference of the time between the Tranſit of Weſt Limb of the Sun, and the body of ☿ under the ſame Meridian collected from the Pendulum Vibrating ½ of a ſecond.			The diſtance of ☿ from Center of the Sun.			The apparent altitude of the Sun.		The hour Collected by the Altitude.		
	M.	S.	vib. Pend.	M.	S.	T.	M.	S.	T.	G.	M.	H.	M.	S.
1	0	0	345	1	55	0	1	20	37	27	45	10	53	58
2	2	3	276	1	32	0	5	0	55	29	36	12	0	0
3	2	45	258	1	26	0	5	9	20	29	34	0	9	55
4	3	40	224	1	14	40	4	7	30	29	03	0	35	50
5	5	30	164	0	54	40	7	13	7	25	0	1	44	10
6	6	30	148	0	49	20	8	15	0	24	5	1	55	22
7	6	53	132	0	44	00	9	16	45	22	30	2	11	58
8	8	14	100	0	33	20	12	1	45	19	30	2	39	14
9	8	55	80	0	26	40	14	5	30	17	17	2	57	28
10	9	38	39	0	13	00	16	30	0	13	23	3	26	56

	The time of the Tranſitus.				The Diameter in the Parallel.			The Diameter in a great Circle.		
of the Sun.	414	2	18		34	30	0	43	0	0
of Mercury.	3½	0	1	10	0	17	30			

From this Obſervation he had the Declination of Mercury in reſpect of the Parallel through the Center of the Sun, and thence its abſolute Declination from the Equator, ſuppoſing the place of the Sun according to *Hecker*, and the obliquity of the Ecliptick, 23, 30′ the right Aſcenſion alſo of ☿ appeared by the difference of time between the Tranſit of ☿ and the Weſt limb of the Sun by the ſame meridian. Then from the Declination and right Aſcenſion of ☿ given by Trigonometrical Calculation, he found out the Longitude and Latitude of it in every Obſervation, and the time of its true Conjunction.

The

	The time of the phaſes obſerved.			*Heckers* place of the ☉ in ♏			The Decl. of ♀ South aſcen.			The right Aſcenſion of Mercury.			The N. Lat. of ♀ aſcen.		The Long. of Mercury in ♏		
	H.	M.	S.	G.	M.	S.	G.	M.	S.	G.	M.	S.	M.	S.	G.	M.	S.
1	10	53	58	15	33	55	16	32	33	223	16	40	3	10	15	44	48
2	12	0	0	15	36	41	16	31	38	223	13	43	3	14	15	40	40
3	0	9	55	15	37	6	16	30	43	223	12	37	3	53	15	40	30
4	0	35	50	15	38	11	16	30	7	223	10	51	3	55	15	38	27
5	1	44	10	15	41	3	16	29	7	223	8	54	4	15	15	36	3
6	1	55	22	15	41	31	16	28	12	223	7	59	4	55	15	35	6
7	2	11	58	15	42	13	16	28	4	223	7	36	4	56	15	34	40
8	2	39	14	15	43	22	16	27	4	223	7	4	5	48	15	34	5
9	2	57	28	15	44	8	16	26	36	223	6	10	5	57	15	33	0
10	3	26	56	15	45	23	16	26	15	223	5	50	6	12	15	32	37

Therefore the time of the true conjunction of the Sun and Mercury at *Avignon*, was *Nov.* 7. *Hor.* 2. *Min.* 39. *Sec.* 14. Afternoon.

To this he hath adjoyned this enſuing Table, to ſhew how much the Heavens do differ from the Aſtronomical Tables.

Tempus datum ex Tabulis Novemb.	D.	H.	M.	*Differentia ab obſervata conjunctione.* D.	H.	M.	
Rudolphinis Reyneri.	7	8	3	0	7	24	exceſſus.
Calculis Heckeri.	7	6	9	0	5	9	exceſſus.
Lansbergianis.	6	1	12	0	23	27	defectus.
Philolaicis Bullialdi	7	4	18	0	3	39	exceſſus.
Ricciolinis juxta calculum. R. admodum Patris Bonifa. Societatis Jeſu.	7	8	17	0	7	38	exceſſus.

Upon

Theſe Obſervations are delineated in the 23. Figure.

Upon this Obſervation I find in the twenty third Journal de Scavans *of the Year* 1677. *Mr.* Caſſini *made theſe Reflections.*

THat having compared this Obſervation of Monſieur *Gallet*, of 1677. with that of Mr. *Gaſſendus*, of 1631. the ſame day of the year, to wit the ſeventh of *November*, he found that the Latitudes of ☿ at its leaving the Diſc of the Sun, determined by theſe two Aſtronomers were equal, even to the ſixth part of a minute. And by conſequence that ☿ was both in the one and the other Obſervation at the ſame diſtance from its North node, and that it traced in the Diſc of the Sun an equal line: And for that ☿ was here at the like diſtance from its Apoge; as the Sun was alſo pretty near, the ſwiftneſs of its apparent motion in the Sun was equal. By the Obſervation of Mr. *Gallet* it is found conſiderably more ſlow than that which Mr. *Gaſſendus* hath ſuppoſed from the Rudolphin Tables of which he made uſe for the determining of it, not having been able to make Obſervation immediately by reaſon of the Clouds. He believes then that ☿ ſpent more then five hours in running through the Diſc of the Sun, ſince by the Obſervation of Mr. *Gallet*, it hath ſpent 5 hours and 35 minutes, which may ſerve for an Advertiſement for determining more exactly the time of the true conjunction of ☿ with the ☉ in the year 1631.

The ſame equality of Latitude at Mercury's leaving the Sun ſhews that the Sun was equally diſtant from the Node of Mercury at the time of theſe two Obſervations. And as the Sun was more advanced in that of this year from 63 to 64 minutes, than in that of the year 1631, So it follows that the ſeptentrional

Node of ☿ is advanced from 63 to 64 minutes in the ſpace of 46 years, as preciſely as by the Rudolphin Tables, which agree alſo exactly in the Epochas of the Nodes: a matter of no ſmall Importance in Aſtronomy, which hath not a little difficulty to determine with preciſeneſs the Nodes of the Planets and their motions.

But having compared the obſervation of Mr. *Gallet*, with that of Mr. *Hevelius*, in 1661. which happned the third of *May*, in a place of the Zodiac oppoſite to that of this year, he hath found the ſeptentrional Node of ☿ leſs advanced than the Meridional was in the preceding Obſervation; ſo that if the Nodes of ☿ in regard of the Sun are preciſely oppoſite the one to the other, it appears that they have gone backward ſince the year 1661. as do thoſe of the Moon, and by conſequence their motion is ſometimes direct, ſometimes retrograde: But if their motion is ſuppoſed uniform, it will follow that the Line of the Nodes of ☿ doth not paſs at all through the center of the Sun, but that it is removed from it towards the ſeptentrional limit about a two hundredth part of the Semidiameter of the Orb of *Mercury*.

Thus far this knowing and accurate Aſtronomer Monſieur *Caſſini*, who we hear hath ſince farther diſcourſed concerning this matter, which we hope to procure ſo ſoon as he ſhall make it publick; and to add ſome other curious Obſervations made by other hands, I have as yet been able to procure but one more; but that is one ſo conſiderable, that it will excite the skilful Aſtronomers anew to ply their Calculations, to ſee what the comparing of this with the reſt will produce; which as they come to my hands, I deſign to publiſh, as I ſhall alſo ſomewhat of my own Obſervations thereupon: and therefore I omit to make any reflections at preſent. This Letter is of Mr. *Edmund Hally*, now reſiding at St. *Helena*, directed to Sir *Jonas Moore*, Surveyor of his Majeſties Ordnance; a perſon to whom the

the Learned world is very much obliged for his patronizing and promoting theſe Cœleſtial enquiries; who hath not been ſparing of his own pains and purſe in providing the beſt *apparatus* of inſtruments and other conveniences for ſuch Obſervations the world ever had; from whom we may with good reaſon hope a great advancement towards the perfecting thereof.

St. Helena, *Novemb.* 22. 1677.

HOnored Sir, You may with reaſon wonder that I ſhould ſo long be negligent to write to your Worſhip, to give you an account of my proceedings ſince my departure from you, ſeeing that in the buſineſs I am now engaged upon, the Honorable Sir Joſeph Williamſon, *his Majeſties Principal Secretary of State, and your ſelf are my only Patrons: but I have not been unmindful of my Duty in this particular, only I delayed, that what I ſent you might not be altogether inconſiderable. I hoped ſtill that we might have ſome clear weather when the Sun came near our Zenith, that ſo I might give you an account that I had near hand finiſhed the Catalogue of the Southern Stars, which is my principal concern; but ſuch hath been my ill fortune, that the Horizon of this Iſland is almoſt always covered with a Cloud, which ſometimes for ſome weeks together hath hid the Stars from us, and when it is clear, is of ſo ſmall continuance, that we cannot take any number of Obſervations at once; ſo that now, when I expected to be returning, I have not finiſhed above half my intended work; and almoſt deſpair to accompliſh what you ought to expect from me. I will yet try two or three months more, and if it continue in the ſame conſtitution, I ſhall then, I hope be excuſable if in that time I cannot make an end. However it will be a great grief to be ſo far fruſtrated in my firſt undertaking: I have notwithſtanding had the opportunity of obſerving the ingreſs*

and egreſs of ☿ *on the* ☉, *which compared with the like Obſervations made in* England, *will give a demonſtration of the Suns Parallax, which hitherto was never proved, but by probable arguments. Likewiſe I have ſeen thoſe two Eclipſes, one of the Sun, the other of the Moon in* May *laſt, both which I ſend you, but the* mighty winds, and extraordinary ſwift motion of the Clouds *hindred the exactneſs of the Obſervations. That of the Moon may help for the difference of our Meridians, which is about 7 degrees to the Weſtwards of* London: *but it may more curiouſly be found by* Mercury ſub Sole. *There are three Stars of the firſt Magnitude that never appear in* England, *but none near the South Pole of any brightneſs, except one of the third Magnitude, which is about ten degrees diſtant from it. The two Nubeculæ called by the Saylors the* Magellanick *Clouds, are both of them exactly like the whiteneſs of the milky way lying within the Antartick Circle; they are ſmall, and in the Moon ſhine, ſcarce perceptible; yet in the dark the bigger is very notable. I need not relate unto you the temperature of the Weather for heat and cold here in the Torrid Zone, you your ſelf having long ſince had experience of a Latitude little different: only this I ſhall certifie you, that ever ſince I came to this Iſland, we have had no weather that is hotter than the Summer of* England *is ordinarily. Mr.* Clark *is a perſon wonderfully aſſiſtant to me, in whoſe company all the good fortune I have had this Voyage conſiſteth, to me all other things having been croſs: nevertheleſs I deſpair not of his Honors and your Worſhips favour, which alone is ſufficient to encourage me to bear with patience theſe diſappointments, and expect ſome fitter opportunity.*

I am your Worſhips moſt obliged
Servant, and true Honorer,

Edmund Halley.

Octobris

St. Helenæ, Latitudo Auſtralis, 15. 55.

Anno 1677.

Octobris 28. *die* ☉ *mane* ☿ *apparuit intra* ☉.

h.	m.	s.	
9	26	17	*Pars aliqua corporis* ☿*ii intraſſet Solem decem gradus à nadir ad dextram circiter.*
9	27	30	*Formabat angulum contactus totus* ☿ *ſcilicet. intus*
2	38	39	*Limbus* ☿*ii proximus diſſiti à limbo Solis ſui Diametro.*
2	40	8	*Limbus* ☿*ii tetigit limbum* ☉.
2	41	0	*Centrum* ☿ *exiit è Sole 30 grad. circiter à Nadir ad dextram.*
2	41	54	☉ *limbus integer factus.*

Longitudo & Latitudo trium Stellarum illuſtrium prope polum auſtrinum.

	Long.			*Latit.*	
Canopus	11	3	♋	75	49
Centauri pes	25	24	♍	42	22
Alcarnar.	10	31	♓	59	$18\frac{1}{3}$.

The Period of the Revolution of Jupiter *upon it Axis; verified by new Obſervations made by Monſieur* Caſſini:

Extracted out of the Journal de Scavans.

THE Globe of *Jupiter*, whoſe Revolution about its *Axis* was determined by the Obſervations of Monſieur *Caſſini*, in the Year 1665. to be 9 hours, and 56 minutes, is as it were a watch for viſibly pointing the hours and minutes to half the Earth at once; ſo that it ſhews the ſame time to all under the ſame Meridian, and a different time to different Meridians, according as they differ in Longitude.

This Revolution of the body of ♃ upon its *Axis* I firſt diſcovered in *May* 1664. and publiſhed in the firſt Tranſaction, which was a conſiderable time before it was diſcovered by Monſieur *Caſſini*; but we are obliged to him for the perfecting the Theory, as we are alſo for many other rare Diſcoveries and excellent improvements in Aſtronomy.

It hath for an Index of its motion one principal ſpot, which is very neatly diſtinguiſhed from the reſt of its ſurface, and ſeems from its figure and ſituation to have ſome reſemblance to the Caſpian Sea of the Terraqueous Globe. By the help of good Glaſſes it may be ſeen paſſing the under Hemiſphere of it, from the Eaſt to the Weſt, with a velocity ſo ſenſible, that one may determine to one or two minutes, the time that it comes to the middle of the Diſc, which is the place the moſt fit for eſtabliſhing of the Epochas, and for finding the difference of Longitude. There may be a great number of ſuch Revolutions obſerved, ſince in one year of 365 days

days there are made 882 Revolutions. But it doth not appear in every year, but as if it were ſome kind of Mariſh which is dried at certain times, and ſo diſappears during two or 3000 Revolutions; and after it hath remained thus imperceptible for ſome years, it returns again to its former ſtate. After it had been obſerved the laſt ſix months of the year 1665. and ſome months of 1666. it became inviſible till the beginning of the year 1672. then being returned to its former appearance, Monſieur *Caſſini* compared the intervals of the ſix years, and limited the revolution to be made in 9 hours, 55 minutes, 51 ſeconds; and continuing his Obſervations to the end of the year 1674. he found by theſe two years that it was too ſlow by two ſeconds and a half: ſo that it appeared to be in 9 hours, 55 minutes, $53\frac{1}{2}$ ſeconds.

This ſpot hath been inviſible in 1675. and 1676. during which ſpace there happened other very conſiderable changes in the body of *Jupiter*; for the clear interſtice which was between the two dark belts of *Jupiter* was ſeparated into many little parts, in the manner like ſo many Iſlands; as if the two obſcure belts had been two great Rivers broken one into the other, and had left theſe parts which appeared like Iſlands, which yet were at laſt all effaced, and the two dark belts, and the interjacent ſpace at length all coaleſced into one large belt. But after the coming of *Jupiter* out of the Rays of the Sun in the year 1677. the belts again took their form, and ſituation which they had heretofore; to wit, the ſame which is deſcribed in the 24 figure. The principal ſpot appeared anew after the beginning of *July* laſt. Monſieur *Caſſini* found this ſpot in the middle of *Jupiter* the night after the eighth of the ſaid month, at 13 minutes after one at night; and hath hitherto ever ſince obſerved it at the hours proper to its revolution. Having compared many Obſervations of this year with as many others made the ſame days of the year 1665. for avoiding the ſcruples which may a-

riſe

riſe from the inequality of times, he hath found by the intervals of twelve years that thoſe revolutions compared the one with the other, complete themſelves in 9 hours, 55 minutes, 52 ſeconds, and 5 or 6 thirds. And becauſe that in the years 1672, 1673. they appeared more ſlow by 2 ſeconds and a half, during the time that *Jupiter* was in its greateſt elevation from the Sun. Monſieur *Caſſini* inclines to ſuppoſe that theſe revolutions have ſome little inequality depending on the variation of the diſtance of ♃ from the ☉, and that they are a little ſlower when ♃ is more removed, and ſomewhat faſter when nearer approached that body; the ſame which ſeveral great Aſtronomers have ſuppoſed to happen to the Diurnal Revolutions of the Earth in the Copernican Hypotheſis.

In this account he hath ſeparated the inequality which doth reſult from the variation of the two equations of *Jupiter* (as he hath explained in divers Letters in 1665.) the which may amount to one half hour, beſides the inequality of natural days, which according to his Hypotheſis may amount to 16 minutes.

For the finding then of the return of the principal ſpot to the middle of ♃ for many years to half an hour or thereabout, there needs nothing but adding ſtill the time of the period to the Epoche of the 8. of *July*, 1677. and for the finding preciſely, even to ſome minutes, the two inequalities of *Jupiter* muſt be obſerved according to the following Rule.

Differentiam inter medium locum Jovis & apparentem converte in tempus dando ſingulis gradibus min. 1. *hoc tempus adde tempori reſtitutionis maculæ ſupputato, ſi locus apparens Jovis exceſſerit medium: ſubtrahe vero ſi defecerit à medio.*

We have then the mean time of the return of the ſpot, and to get the apparent time the equation of days according to the method of Monſieur *Caſſini* (of which a Table is inſerted in the Ephemerides of Monſieur *Flaminio de Mezzavachi*) muſt be made uſe of.

MI-

MICROSCOPIUM:

OR,

Some new Diſcoveries made with and concerning *Microſcopes.*

A Letter of the Ingenious and Inquiſitive Mr. Leeuwenhoeck *of* Delft, *ſent to the Secretary of the* Royal Society, *October* 5. 1677.

IN this Letter after the Relation of many curious Obſervations made with his Microſcope, he adds, 'By ſome of my former Letters I have related what an 'innumerable company of little Animalcules, I have 'diſcovered in waters; of the truth of which affirma-'tions, that I might ſatisfie the Illuſtrious Philoſophers 'of your Society, I have here ſent the Teſtimonials of 'eight credible perſons; ſome of which affirm they, 'have ſeen 10000, others 30000, others 45000 little 'living Creatures, in a quantity of water as big as a 'grain of Millet (92 of which go to the making up the 'bigneſs of a green Pea, or the quantity of a natural 'drop of water) in the deſiring of which Teſtimonials 'I made it my requeſt that they would only juſtifie '(that they might be within compaſs) half the number 'that they believed each of them ſaw in the water, and 'even ſo the number of thoſe little creatures that would 'thereby be proved to be in one drop of water would 'be ſo great, that it would exceed belief. Now where-'as by my Letter of the 9th. of *October*, 1676. I affirmed 'that there were more than 1000000 living Creatures 'contained in one drop of Pepper-water. I ſhould not

'have varied from the truth of it, if I had aſſerted that 'there were 8000000; for if according to ſome of the 'included teſtimonials there might be found in a quan- 'tity of water as big as a millet ſeed, no leſs than 45000 'animalcules. It would follow that in an ordinary drop 'of this water there would be no leſs than 4140000 'living creatures, which number if doubled will make '8280000 living Creatures ſeen in the quantity of one 'drop of water, which quantity I can with truth af- 'firm I have diſcerned.

'This exceeds belief. But I do affirm, that if a larger 'grain of ſand were broken into 8000000 of equal 'parts, one of theſe would not exceed the bigneſs of one 'of thoſe little creatures; which being underſtood, it 'will not ſeem ſo incredible to believe that there may 'be ſo great a number in the quantity of one drop of 'water.

Upon the peruſal of this Letter, being extremely deſirous to examine this matter farther, and to be aſcertained by ocular inſpection as well as from teſtimonials. I put in order ſuch remainders as I had of my former Microſcopes (having by reaſon of a weakneſs in my ſight omitted the uſe of them for many years) and ſteeped ſome black pepper in River water, but examining that water about two or three days after, I could not by any means diſcover any of thoſe little creatures mentioned in the aforeſaid Letter: though I had made uſe of ſmall glaſs canes drawn hollow for that purpoſe, and of a Microſcope that I was certain would diſcover things much ſmaller than ſuch as the aforeſaid Mr. *Leeuwenhoeck* had affirmed theſe creatures to be; but whether it were that the light was not convenient (the reaſon of which I ſhall ſhew by and by) having looked only againſt the clear ſky, or that they were not yet generated, which I rather ſuppoſe, I could not diſcover any. I concluded therefore either that my Microſcope was not ſo good as that he made uſe of, or that the time of the year

year (which was in *November*) was not ſo fit for ſuch generations, or elſe that there might be ſomewhat aſcribed to the difference of places; as that *Holland* might be more proper for the production of ſuch little creatures than *England*. I omitted therefore farther to look after them, for about five or ſix days, when finding it a warm day, I examined again the ſaid water; and then much to wonder I diſcovered vaſt multitudes of thoſe exceeding ſmall creatures, which Mr. *Leeuwenhoeck* had deſcribed; and upon making uſe of other lights and glaſſes, as I ſhall by and by ſhew, I not only magnified thoſe I had thus diſcovered to a very great bigneſs, but I diſcovered many other ſorts very much ſmaller than thoſe I firſt ſaw, and ſome of theſe ſo exceeding ſmall, that millions of millions might be contained in one drop of water. I was very much ſurprized at this ſo wonderful a ſpectacle, having never ſeen any living creature comparable to theſe for ſmallneſs: nor could I indeed imagine that nature had afforded inſtances of ſo exceedingly minute animal productions. But nature is not to be limited by our narrow apprehenſions; future improvements of glaſſes may yet further enlighten our underſtanding, and ocular inſpection may demonſtrate that which as yet we may think too extravagant either to feign or ſuppoſe.

Of this, A later Diſcovery of Mr. *Leeuwenhoeck* does ſeem to give good probabilities; for by a Letter of his ſince ſent (the which is hereunto annexed) it appears he hath diſcovered a certain ſort of Eels in Pepper-water, which are not in breadth above one thouſandth part of the breadth of a hair; and not above a hundredth part of the length of a vinegar Eel.

Mr. Leeuwenhoecks *Second Letter.*

SIR, 'Yours of the thirtieth of *November* I received 'not till *January*, whereby underſtanding the kind 'reception of my former by the *R. S.* I here return my 'acknowledgment to that illuſtrious Company for their 'great civility: but I wonder that in your Letter I find 'no mention made of my Obſervations of the ſecond of '*December*, *St. No.* which makes me doubt whether the 'ſame came to your hands.

'Since you aſſure me that what I ſend of this nature 'will be acceptable to the renowned Society, I have ad- 'ventured again to ſend you ſome of my farther Enqui- 'ries, to be communicated to that learned Philoſophical 'Company. Since I wrote of the Blood of Eels, and 'of young Eels, I have not been idle to view Blood, 'but eſpecially my own, which for ſome time I have in- 'defatigably examined, after that I had put it into all 'conceivable motions. Among which Obſervations I 'well ſaw that the *globuli* of my own blood took the 'ſame figure which I formerly mentioned, that the Glo- 'bules of the blood of Eels appeared of to the eye: 'upon ſeeing which I doubted again at the cauſe of the 'ſmart which the blood of the Eels cauſes in the eye.

'Theſe my many times repeated Obſervations of my 'own blood I made to no other end, than if it were poſ- 'ſible, to obſerve the parts out of which the Globules 'of the blood conſiſted: With obſerving this, I found 'the globulous blood much more pliable than I did ima- 'gine the ſame before. I have at ſeveral times bended 'theſe Globules before my eyes, that they were three 'times as long as broad, without breaking the Veſicule 'of them: and beſides I ſaw that the Globules of blood 'in paſſing by and through one another, did, by reaſon 'of their pliableneſs receive many ſorts of figures, and 'coming thence into a larger place, they recovered their former

'former globuloſity which was a very great pleaſure 'to obſerve: and withal, that the Globules of blood 'coming many together, and growing cold thereby, 'came to unite, and made a matter very ſmooth, 'wherein there were no more parts diſtinct to be taken 'notice of, much after the ſame manner as if we ſup-'poſed a Diſh filled with balls of wax ſet over a fire, 'by which they would quickly be melted together, and 'united into one maſs; by which uniting of the Glo-'bules, I concluded this to be the reaſon of the acci-'dent which is called the *cold fire*, and of that alſo 'which cauſes the hands or fingers to be loſt by cold: 'but I leave this to others. And I did very clearly alſo 'diſcover that there were ſix other ſmaller Globules of 'blood contained within each of the former and lar-'ger Globulous Veſicles: and withal, I took much 'pains to obſerve the number of the ſame very ſmall 'globules, out of which the greater Globules do con-'ſiſt: that at laſt I ſtrongly imagined, that every of the 'greater Globules conſiſted of ſix ſmaller Globules, no 'leſs pliable than the aforeſaid: for oftentimes I ſaw 'very clearly how the ſmall Globules joyned and ada-'pted themſelves according to the figure the Veſicle 'or larger Globule ſtretched at length had taken, being 'themſelves ſtretched after the ſame manner: and thus 'made one of the larger Globules ſtretcht out, to ap-'pear by the leſſer within it ſtretched alſo with it, 'as if it conſiſted of long threads. Moreover, I 'put the greater Globules into ſo violent a motion, that 'their Veſicles burſt in pieces, and then the leſſer Glo-'bules appeared plainly to be ſcattered. This firſt 'Globule I can ſee as plainly and great, as with the na-'ked eye one ſhould look upon the eggs or ſpawn of a 'Cod-fiſh.

'About nine or ten years ſince Dr. *Graff* opened in 'my preſence the vein of a Dog, and let out ſo much 'blood that the Dog grew faint; then he opened the 'Artery of another Dog, and by a pipe transfuſed the

'blood of this ſecond into the firſt, whereby the firſt 'was recovered, the ſecond was faint. Then the ſaid Do-'ctor injected back into the Artery of the ſecond, a 'quantity of Cows milk, ſuppoſing thereby to preſerve 'the ſecond dog alive, ſaying, milk was blood: but 'no ſooner was the milk put into the artery, but the 'dog died. And whereas 'tis commonly ſaid that milk 'is Blood, therefore I ſhall relate of what parts the 'Milk conſiſts, ſo far as I have hitherto diſcovered. I 'have ſaid heretofore that the Milk doth conſiſt of 'Globules ſwimming in a thin clear watery matter 'which we call Whey: but as the great *Globuli* of 'Blood are all of the ſame bigneſs, ſo in the Milk they 'are quite differing, being of as many ſizes and magni-'tudes as we can imagine, between the ſmalleſt ſand, 'and a barley corn; all of them being as clear as Cry-'ſtal; ſave only that through and between the ſame 'drive ſome irregular particles for the moſt part roun-'ded: theſe had a fatty ſubſtance, which I imagined 'to be the latter: their irregularity I imagined came 'from the impreſſion of the encompaſſing Globules 'made on them, in which poſture they grew cold.

'Viewing the aforeſaid differences of the Milk Glo-'bules, I ſuppoſed that the Milk veſſels have no 'other parts included but the matter out of which they 'are all made; and that the ſame matter, ſo long as in-'cluded in the veſſels, conſiſted of one uniform matter, 'ſo that one could not diſtinguiſh parts; and that the 'ſame veſſels diſcharging this uniform matter into other 'veſſels, containing a ſubſtance of a quite differing na-'ture, which I ſuppoſe to be the Whey, comes to be 'ſeparated into theſe Globules of ſo differing magni-'tudes. This may be repreſented by having two veſ-'ſels filled, the one with Fat, repreſenting Whey; the 'other with Quickſilver, reſembling the uniform mat-'ter of the Milk: theſe blended together, the Quick-'ſilver will be ſeparated into ſmall Globules of differing 'magnitudes, and kept diſtinct by the fat.

Or

'Or further, it may be explained by a diſſolution of 'ſome gums in Spirit of Wine, a drop of which being 'put into rain water (which I compare to Whey) the 'Gum becomes ſeparated immediately into an incredi-'ble number of ſmall clear Globules, which makes it 'appear alſo as white as Milk it ſelf: and thence I ſup-'poſe that the whiteneſs of Milk hath the ſame cauſe.

'I have been often minded by ſome, that fleſh was 'nothing elſe but clodded blood; yet for all my en-'deavours I was never able to find the firſt particles of 'blood in the fibers of the fleſh, but only ſuch as are 'contained in the firſt Globules.

'The laſt Summer being ſickly for ſome weeks, I 'voided much Flegm, which was green, tough, and 'acid in the throat, which yet continues; but nothing 'near ſo much as before: and ſome of it which I void-'ed in the morning was of ſo heavy a matter, that it 'ſunk in the water: the ponderoſity of it I found to 'proceed from its not being filled with airy bubbles, 'which moſt Flegms are mixed with. By this means I 'obſerved my Flegm very often, and found it to con-'ſiſt of tough ſlimy moiſture, mixt with many Globules; 'and the tougher the Flegm was, the greater was the 'quantity of Globules; and from them alſo proceed-'ed the green colour of it. All theſe Globules were of 'one and the ſame bigneſs with the firſt Globules of 'the blood; and indeed the blood is of the ſame 'make, but only of a different colour: for as I ob-'ſerved the greater blood Globules to conſiſt of ſix 'leſſer, ſo here I could ſee them more plain; only they 'ſeemed more ſlender and tender than in the blood: 'the reaſon whereof I ſuppoſe to be that the veſicules of 'the Flegm Globules had already received ſome kind 'of corruption: beſides, there was mixt with the tough 'part of the Flegm great quantity of very thin cuti-'cles: and in the ſame manner as I have heretofore ex-'plained how our cuticle is ſupplied underneath, as the 'upper part is rubbed off in ſcurf, ſo I ſuppoſe the in-

ner

'ner cuticles of the gullet *aſpera arteria*, and other veſ-
'ſels are taken off by the Flegm. There drove alſo,
'through the Flegm ſome other particles, which from
'their ſmallneſs I could not aſſign them a figure, but I
'conceived them rather cubical than round. I did laſt
'Summer ſhut up ſome Caterpillers to ſpin Webs, and
'within theſe few days I broke ſome of theſe Webs,
'when from each of them came out a flie, which from
'the cold were very weak, and were unable to ſtand;
'by which I conceive that thoſe which came not out in
'the latter part of the year, remain the whole Winter
'in their Webs, till the warmth makes them come out.
'I was pleaſed to underſtand that your ſelf and the
'*Society* had ſeen in ſo ſmall a quantiy of water as a
'ſand, ſo great a number of Creatures; as alſo, that I
'ſhall be partaker of what you ſhall obſerve, which I
'ſhall with longing deſire expect. I cannot but men-
'tion that that ſmall ſort of Creature which I hereto-
'fore could give no deſcription of, I now ſee their fi-
'gure. And for the pleaſure I take in the various plea-
'ſing ſhapes, with their motions, which do now and
'then appear in the water, I have the fourth of this
'month, when it froze hard, taken a third part of beat-
'en pepper, and $\frac{2}{3}$ of high rain water in a clean glaſs,
'which I ſet the firſt night in my Bed-chamber; the next
'day, the weather being milder, I ſet it in my Counting-
'houſe, and in three times 24 hours diſcovered ſo
'great a number, and ſo unexpreſſible ſmall Creatures,
'that 'tis hard to be conceived; and according to my
'judgment, the moſt of them were much leſs than a
'thouſandth part of the thickneſs of the hair of ones
'head, and three or four times as long as thick; the
'which made, with the hinder part of their body, oft-
'times ſo ſwift a progreſs, as when we obſerve a Pike
'ſhooting through the water, and every ſhoot was in
'length moſt times about half a hairs breadth; the
'other ſorts or kind of which were yet ſmaller, whoſe
'ſhape for brevity I omit; only I ſhall ſay, that oft-

times

'times in pepper-water which hath ſtood ſomewhat 'long, among the very ſmall Creatures, I have ſeen a 'ſort of ſmall Eels which had their ſhapes and moti-'ons as perfect as great ones: theſe were to my 'appearance a thouſand times thinner than the hair of 'ones head, and that if 100 of theſe ſmall Eels were 'laid in length one behind another, the whole length 'would not extend to the length of the Eel in vine-'gar: Whether you have alſo obſerved theſe ſmall 'Creatures with your Microſcope, I ſhall be glad to un-'derſtand. I would willingly alſo be informed whether 'my Letter of the ſecond of *December* mention'd above 'be come to your hands, and how thoſe Obſervations 'do pleaſe the Gentlemen of your Society; and alſo 'to underſtand the receipt of this.

The manner how the ſaid Mr. *Leeuwenhoeck* doth make theſe diſcoveries, he doth as yet not think fit to impart, for reaſons beſt known to himſelf; and therefore I am not able to acquaint you with what it is: but as to the ways I have made uſe of, I here freely diſcover that all ſuch perſons as have a deſire to make any enquiries into Nature this way, may be the better inabled ſo to do.

Firſt, for the manner of holding the liquor, ſo as to examine it by the Microſcope, I find that the way preſcribed by Mr. *Leeuwenhoeck* is to include the ſame in a very fine pipe of glaſs, and then to view it by the help of the Microſcope; for by placing that at a due diſtance, whatever is contained in the ſaid liquor will moſt eaſily be diſcovered: The liquor will moſt eaſily inſinuate it ſelf into the cavity of the ſaid pipe, if the end thereof only be juſt put within the liquor. This as it is exceedingly convenient for many trials, ſo is it not very difficult to prepare; but becauſe every one is not inſtructed how to proceed in this matter, and it may cauſe him more trouble than needs to procure them, I will here deſcribe the way; and ſo much the rather, becauſe the ſame *apparatus* will

ſerve for the preparing of Microſcopes: as I ſhall afterwards ſhew.

Provide then a box made of tin, with a flat bottom, and upright on all ſides; let this have fixed within it to the bottom a ſmall piece of tin, hollowed like a ridg tile, ſo that the wiek of the Lamp may lie and reſt upon it, and let the Tin-man fix on it a cover of tin, ſo that there may be only left one part of the aforeſaid box open, to wit, where the bent tin piece and the wiek do lie and come above the ſides: this cover may be turned back on its hinges when there is occaſion to raiſe the wiek, or put in more oyl, *&c.* but for the moſt part ought to lie flat and covered; for whilſt it is uſing, it is neceſſary to keep the flame from ſpreading too much, and taking fire all over. This box muſt ſtand within another box of tin, made large enough to contain it; the uſe of which is to keep the former Lamp Box from fowling the board or table on which it ſtands: This ſtands upon a board about one foot ſquare, into which is faſtned a ſtandard or ſtick upright, cleft ſo as to pinch and hold the ſodering pipe between its clefts, which may be faſtned with a ſcrew, or a ſlipping ring; through which pipe, blowing with your breath, the flame will be darted forward with great ſwiftneſs and brightneſs: if then into this flame you hold a ſmall piece of a glaſs pipe, made of white glaſs, (for green glaſs, or coarſer glaſs will not be melted eaſily in this flame) and keep it turning round between your fingers and thumbs, you ſhall find that the flame will in a very ſhort time melt the middle part of the ſaid pipe; ſo that if you remove it out of the flame, and draw your hands one from another, you may eaſily draw the former pipe into a very ſmall ſize, which will yet remain hollow, though drawn never ſo ſmall. The beſt Oyl for this purpoſe is good clean Sallat Oyl, or Oyl Olive; but high rectified Spirit of Wine is yet better, and cleanlier, but much more chargeable; and for moſt uſes the Oyl Olive will ſerve. This I have ſet down, be-

cauſe

cauſe many who are far off in the Country cannot have the convenience of going to a Lamp-blower as oft as they have occaſion for ſuch pipes; which if they provide themſelves with ſmall white glaſs pipes from the Potters, they may accommodate themſelves withal, though they have nothing but a large candle, and a tobacco-pipe, inſtead of the aforeſaid *apparatus*, though not altogether ſo conveniently. But I would rather adviſe them to have a Lamp made, which moſt Tin-men know how to fit and prepare; and ſo it will not need much more deſcription.

But this way of Mr. *Leeuwenhoecks*, of holding the liquors in ſmall glaſs pipes, though it be exceedingly ingenious, and very convenient for many examinations, yet for divers others 'tis not ſo well accommodated as this which I contrived my ſelf for my own trials, at leaſt for thoſe Microſcopes I make uſe of; what it may be for thoſe which Mr. *Leeuwenhoeck* uſes I know not.

I take then inſtead of a glaſs pipe a very thin plate of *Muſcovy* glaſs, this ſerves inſtead of the moveable plate which is uſually put upon the pedeſtal of Microſcopes; but becauſe the common pedeſtal hitherto made uſe of in Microſcopes is generally not ſo convenient for trials of this nature, I lay thoſe by, and inſtead thereof I fix into the bottom of the Tube of the Microſcope, a cylindrical rod of Braſs or Iron. Upon this a little ſocket is made to ſlide to and fro; and by means of a pretty ſtiff ſpring, will ſtand faſt in any place. This hath faſtned to it a joynted arm of three or four joynts, and at the end a plate about the bigneſs of a half crown, with a hole in the middle of it about three quarters of an inch wide; upon this plate I lay the *Muſcovy* glaſs, and upon that I ſpread a very little of the liquor to be examined; then looking againſt the flame of a Candle, or a Lamp, or a ſmall reflection of the Sun from a globular body; all ſuch parts of the liquor as have differing refraction will manifeſtly appear. By this means I examined the water in which

I had ſteeped the pepper I formerly mentioned; and as if I had been looking upon a Sea, I ſaw infinite of ſmall living Creatures ſwimming and playing up and down in it, a thing indeed very wonderful to behold.

If the flame of the candle were directly before the Microſcope, then all thoſe little Creatures appeared perfectly defin'd by a black line, and the bodies of them ſomewhat darker than the water; but if the candle were removed a little out of the axis of viſion, all thoſe little Creatures appeared like ſo many ſmall pearls, or little bubbles of air, and the liquor in which they ſwimmed appeared dark; but when the water began to dry off, the bending of the ſuperficies of the liquor over their backs, and over the tops of other ſmall motes which were in the water made a confuſed appearance, which ſome not uſed to theſe kind of examinations, took to be quite differing things from what they were really; and the appearances here are ſo very ſtrange, that to one not well accuſtomed to the phænomena of fluids of differing figures and refractions, the examinations of ſubſtances this way will be very apt to miſ-inform, rather than inſtruct him; eſpecially of ſuch ſubſtances as are not perfectly fluid, and will not readily and naturally ſmooth their own ſuperficies, ſuch as Tallow, concreted Oyls, Marrow, Brains, Fat, inſpiſſated juyces, *&c.* for if thoſe ſubſtances be ſo examined by ſpreading them upon this plate, and be looked upon againſt the candle, or other ſmall defined light, all the inequalities left on the ſurface by the ſpreading do by the refractions of the rays of light render ſuch odd appearances, that they will eaſily deceive the examinator, and make him to conceive that to be in the texture of the part which is really no where but in the make of the ſuperficies of it. This therefore as another great inconvenience to be met with in Microſcopical Obſervations, I prevent by theſe enſuing methods: Firſt, all ſuch bodies as Fat, Oyl, Brains, Rhobs, *Pus*, tough concreted Flegm, and the like, whoſe ſurfaces

are

are irregular, and ought to be reduced to ſmoothneſs before they can be well examined, I order in this manner: Firſt, I provide a very clear and thin piece of looking-glaſs plate very ſmooth and plain on both ſides, and clean from foulneſs: upon the ſurface of this I lay ſome of thoſe ſubſtances I laſt mentioned, then with ſuch another piece of Looking-glaſs plate laid upon the ſaid ſubſtance I preſs it ſo thin as not only to make the ſurfaces of it very ſmooth, but alſo to make the ſubſtance of it very thin; becauſe otherwiſe, if the ſubſtance be pretty thick, as ſuppoſe as thick as a piece of *Venice* paper, if it be a whitiſh ſubſtance, the multitudes of parts lying one upon another in ſuch a thickneſs, do ſo confound the ſight, that none of them all can be diſtinctly ſeen: but if by ſqueezing the ſaid plates hard, and cloſe together, it be reduced to a twentieth part perhaps of that thickneſs, the ſubſtance may be well looked through, and the conſtituent parts may be very plainly diſcovered. Thus alſo 'tis very viſible in the Globules of milk and blood, diſcovered by the ingenious Mr. *Leeuwenhoeck*, for when either of thoſe ſubſtances are thick, the multitude of thoſe little Globules confound and thicken the liquor ſo as one cannot perceive any thing until it be run very thin; for then all the remaining Globules with their motions may very diſtinctly be apprehended. This therefore is an expedient by which thouſands of ſubſtances may be examined; and therefore the more fit to be communicated, that there may be the greater number of obſervers well accommodated for ſuch trials. Theſe plates therefore may be contrived ſo as to be pinched together by the help of ſcrews, and a frame, that thereby they may be forced the cloſer and the evener together, as there ſhall be occaſion; and may be kept firm and ſteady in that poſture, and then, that it may ſome ways or other be conveniently faſtned to the former plate, ſo as to be moved this way or that way ſteadily, as there ſhall be occaſion.

But there are other ſubſtances which none of theſe ways I have yet mentioned will examine, and thoſe are ſuch parts of animal or vegetable bodies as have a peculiar form, figure, or ſhape, out of which if it be put, the principal thing looked after is deſtroyed: ſuch are the Nerves, Muſcles, Tendons, Ligaments, Membranes, Glandules, Parenchymas, *&c.* of the body of Animals, and the Pulps, Piths, Woods, Barks, Leaves, Flowers, *&c.* of Vegetables. Some of theſe which are not made by diſſection or ſeparation from other parts may be viewed alone; but there are others which cannot be well examined unleſs they be made to ſwim in a liquor proper and convenient for them: as for inſtance, the parts of fleſh, muſcles and tendons: for if you view the fibres of a muſcle encompaſſed only with the air, you cannot diſcover the ſmall parts out of which it is made: but if the ſame be put into a liquor, as water, or very clear oyl, you may clearly ſee ſuch a fabrick as is truly very admirable, and ſuch as none hitherto hath diſcovered that ever I could meet with; of which more hereafter, when I ſhew the true mechanical fabrick thereof, and what cauſes its motion. Thus if you view a thred of a Ligament, you ſhall plainly ſee it to be made up of an infinite company of exceeding ſmall threads ſmooth and round, lying cloſe together; each of which threads is not above a four hundredth part of the bigneſs of a hair: for comparing thoſe of Beef with a hair of my head, which was very fine and ſmall, *viz.* about a 640. part of an inch, I found the Diameter thereof to be more than twenty times the Diameter of theſe threads; ſo that no leſs than 163 millions, beſides 840 thouſands of theſe muſt be in a ligament one inch ſquare. I ſhall not here enlarge upon the admirable contrivance of Nature in this particular, nor ſay any thing farther of the reaſon of the greater ſtrength of the ſame ſubſtance drawn into ſmaller than into greater threads; but only this in general, that the mechanical operations of theſe minute bodies

bodies are quite differing from thoſe of bodies of greater bulk, and the want of conſidering this one thing hath been the cauſe of very great abſurdities in the Hypotheſes of ſome of our more eminent modern Philoſophers: For he that imagines the actions of theſe leſſer bodies the ſame with thoſe of the larger and tractable bodies, will indeed make but *Ariſtotles* wooden hand at beſt. This put me in mind likewiſe of advertiſing the Experimenter that he provide himſelf with inſtruments, by which, to ſtretch and pull in pieces any ſubſtance whilſt the ſame is yet in view of the Microſcope, of which there may be many which any one will eaſily contrive, when he hath this hint given him of the uſefulneſs thereof in the examination of the texture of ſeveral ſubſtances; as of Tendons, Nerves, Muſcles, *&c.* thoſe I have made uſe of were made to open like a pair of Tobacco Tongues, by two angular plates of thin braſs rivetted together, which by pinching the oppoſite end, would either open or ſhut at the other, as I had occaſion. Theſe having a part extended between the two tops, were fixt at a due diſtance from the object-glaſs that the body extended between them might be diſtinctly ſeen; then with my finger ſqueezing together the oppoſite ends, the other ends opened, by which means how the parts ſtretched and ſhrunk might be plainly diſcovered. Now as this is of uſe for ſome kind of ſubſtances, ſo the two glaſs plates are for others, and particularly for ſqueezing of ſeveral ſubſtances between them, ſo as to break them in pieces, as thoſe little Creatures in pepper-water, or the Globules in blood, milk, flegm, *&c.* whereby the parts within them may yet farther be enquired into, as Mr. *Leeuwenhoeck* I find hath done by his lateſt Obſervations. Whether he makes uſe of this way, or ſome other, I know not.

Having thus given a deſcription of the appurtenances, it remains that I come to the deſcription of the Micro-

croſcope it ſelf, which is the principal inſtrument, and without which all the reſt are inſignificant.

The Microſcopes then I deſign here to deſcribe, are only of two kinds, either ſingle or double.

The ſingle Microſcope I call that which conſiſteth only of one glaſs, though it have a double refracting ſuperficies; and the double one I call that which is compounded of two glaſſes, though it hath for the moſt part a quadruple refraction of the Rays.

The ſingle Microſcope then conſiſteth of one ſmall *lens* ſo faſtened into a cell, that the eye may come conveniently to look through the middle part or *Axis* of it; of theſe there are various ſorts, as double Convexes, or plain Convexes, or perfectly ſpherical.

I ſhall not need to deſcribe the common *lenſes* which are every where made uſe of for this purpoſe, being plano-convexes of Spheres about half an inch Diameter, ſave only this, that 'tis beſt to turn the plain ſide towards the object, and the convex to the eye: nor ſhall I ſay much concerning thoſe double Convex Glaſſes, there being no great difficulty in the making or uſing of them; but that the ſmaller the ſphere is in which they are made, the nearer do they bring the object to the eye; and conſequently the more is the object magnified, and the better and truer they are poliſht in the Tool, the more clear and diſtinct doth the object appear, but to make any of a Sphere leſs than $\frac{1}{15}$ of an inch in Diameter is exceeding difficult, by reaſon that the glaſs becomes too ſmall to be tractable; and 'tis very difficult to find a cement that will hold it faſt whilſt it be completed; and when 'tis poliſht, 'tis exceeding difficult to handle and put into its cell: beſides, I have found the uſe of them offenſive to my eye, and to have much ſtrained and weakened the ſight, which was the reaſon why I omitted to make uſe of them, though in truth they do make the object appear much more clear and diſtinct, and magnifie as much as the double Microſcopes: nay, to thoſe whoſe eyes can

well

well endure it, 'tis poſſible with a ſingle Microſcope to make diſcoveries much better than with a double one, becauſe the colours which do much diſturb the clear viſion in double Microſcopes is clearly avoided and prevented in the ſingle. The ſingle Microſcope therefore which I ſhall here deſcribe, as it is exceeding eaſie to make, ſo is it much more tractable than the double Convex glaſſes made the common way by working them in a hollow Hemiſphere with water and ſand; for thoſe, ſuppoſing them made with all the accurateneſs imaginable, will be far ſhort from being ſo well poliſht as theſe; and wanting the ſtem or handle which theſe have, they are infinitely troubleſome to remove, or place, or to cleanſe when there ſhall be occaſion.

Take then a ſmall rod of the cleareſt and cleaneſt glaſs you can procure, free if poſſible from blebbs, ſands, or veins; then by melting it in the flame of a Lamp made with Spirit of Wine, or the cleaneſt and pureſt Sallet Oyl, draw it out into exceeding fine and ſmall threads; then take a ſmall piece of theſe threads, and in the ſame flame of the aforeſaid Lamp melt the end of it, till you perceive it to run into a little ball or globule of the bigneſs deſired; then ſuffer it to cool, and handling it by the aforeſaid thread of glaſs, which is as it were a handle to it, fix it with a little wax upon the ſide of a thin plate of Braſs, Silver, or the like, that the middle of it may lie directly over the middle of a ſmall hole pricked through the ſaid thin plate with a needle: then holding this plate cloſe to the eye, look through the ſaid little hole, and thereby you may alſo ſee very clearly through the aforeſaid Globule, fixed with wax on the ſide that is from the eye: if then either by a little joynted arm, or by a little ſoft wax, and a needle, or a thin plate of Muſcovy glaſs, you fix the object you would examine; ſo that it may be at a due diſtance from the ſaid little Globule, you will perceive the minute parts thereof very diſtinct. The *focus* of a ſphere looked on by the naked eye, is about half the *radius* of the

ſphere, without the ſuperficies of it; but this is varied much by the age of the eye that looks through it, by the imagination alſo of the perſon, and by the differing ſpecifique refraction of the glaſs made uſe of.

By this means I have prodigiouſly magnified ſome ſmall bodies, inſomuch that I have been able to ſee and diſtinguiſh the particles of bodies, not only a million of times ſmaller than a viſible point, but even to make thoſe viſible, whereof a million of millions of them would hardly make the bulk of the ſmalleſt viſible ſand; ſo prodigiouſly do theſe exceeding little Globules of glaſs inlarge the proſpect of humane ſight into the more private receſſes of nature.

If the things to be viewed be liquors, they may be included either in thoſe little pipes of Mr *Leeuwenhoeck* I newly mentioned, or elſe they may be put upon exceeding thin plates of *Muſcovy* glaſs or *Selenites*, and the other ſide of the plate may be made to touch the Globule, or at leaſt be fixed at ſuch diſtance, as may make the parts of the liquor diſtinct: If you make uſe of a Looking-glaſs plate to ſpread the liquor upon you would examine, you may turn the liquor towards the Globule, and you may therein eaſily ſee all the parts very diſtinctly, without at all hurting the proſpect by the interpoſition of the *Muſcovy* glaſs; which though it be exceeding clear, eſpecially if the plates be very thin, yet hath it ſome flaws, and ſome opacouſneſſes in it, which do ſomewhat cloud the proſpect.

If further, you would have a Microſcope with one ſingle refraction, and conſequently capable of the greateſt clearneſs and brightneſs that any one kind of Microſcopes can poſſibly be imagined ſuſceptible of, when you have fixt one of theſe little Globules as I have directed, and ſpread a little of the liquor upon a piece of Looking-glaſs plate, then apply the ſaid plate with the liquor, next to the Globule, and gently move it cloſe to the Globule, till the liquor touch; which done, you will find the liquor preſently to adhere to the Glo-

Globule, and ſtill to adhere to it though you move it back again a little; by which means, this liquor being of a ſpecifique refraction, not much differing from glaſs, the ſecond refraction is quite taken off, and little or none left but that of the convex ſide of the Globule next the eye; by which means as much of the inconvenience of refraction as is poſſible is removed, and that by the eaſieſt and moſt practicable expedient that can be deſired. I could add various other ways of making theſe Globular bodies both of glaſs and other ſubſtances which will yet farther advance our proſpect into nature, and are pleaſant to admiration; but thoſe I ſhall yet reſerve till I ſee what effects the publiſhing of theſe may produce, and to the end to excite other perſons to be inquiſitive into this matter: for let me aſſure them, very much more may yet be done by a way I know, than by this I have here publiſhed. And I confeſs I have very often wondered that no farther improvement had been made of this Principle, ſince I publiſht it in the year 1664. in the 20. page of my Preface to *Micrographia*: for though ſome other reaſons diſcouraged me from proſecuting thoſe enquiries, yet I hoped that others might long before this have carried it much farther.

The only inconvenience in theſe kinds of Microſcopes, is, that the object is neceſſarily brought ſo near the glaſs, that none but ſuch as are tranſparent, and to be viewed by a through light are capable of examination by them: ſuch therefore are to be examined by the double Microſcope; which, as it is abundantly more tractable, ſo doth it much leſs ſtrain the eye; and from the eaſineſs of its uſe, when well fitted, is much more pleaſant: and if ordered as it ought, will magnifie as much more than the common ones hitherto made, as thoſe did more than the naked eye.

Both theſe Microſcopes I have directed Mr. *Chriſtopher Cock*, in *Long-Acre*, how to prepare, that ſuch as will not trouble themſelves in the making of them, may know

where to be accommodated with ſuch as are good.

And of the improvement of this kind of Microſcope, I ſee no limits, eſpecially as to the augmenting the viſible appearance of ſuch objects as are capable of enduring the increaſe of light; for ſince 'tis demonſtrable that light may be augmented upon any one object ſuſceptible to any given degree, and that by the double Microſcope the image can be augmented to any aſſigned magnitude, what but the difficulty of making all things correſpondent ſhould limit the power of ſuch an inſtrument. Now the making of this double Microſcope, though it be ſomewhat more difficult than of the ſingle one, yet the tractableneſs thereof when well fitted, and its eaſineſs to be cleanſed, and applied to uſe, makes amends for the extraordinary charge, eſpecially the ſituation of the object; which being capable of any reaſonable diſtance from the object glaſs, ſo as to be fit for examination, makes it very deſirable. Now as in all other mechanical contrivances, that is beſt which is plaineſt, and moſt ſimple: ſo is it in this, wherein nothing more is required, but two plano Convex glaſſes, the one for the object-glaſs, and the other for the eye-glaſs: the leſs the ſpheres of the glaſſes be, the more do they magnifie the object; and the thinner and clearer the ſubſtance of them be, and the more exactly ſhaped, and the brighter they are poliſht, the clearer do they repreſent it; and the longer the glaſſes are diſtant from each other, the more is the image magnified, *cæteris paribus*, though indeed the ſame thing is performed by glaſſes of very differing magnitudes, due proportions of all things about it being kept and obſerved. For if as the diſtance of one object from the object-glaſs is to the diſtance of another object from another object-glaſs, ſo the diſtance of the firſt image be to the diſtance of the ſecond image, the image in both muſt be equal: if therefore this image be viewed with equal glaſſes the image muſt be equally magnified at the bottom of the eye; ſo that in this way the object is capable

capable of a double way of augmenting, *viz.* firſt, the augmenting the figure in the Tube, by the ſmallneſs of the object-Glaſs, and lengthof the Tube: and ſecondly, by the augmenting that image in the bottom of the eye, and that is by the Eye-glaſs; give therefore light enough to the object, and you may increaſe the image at the bottom of the eye to what proportion you ſhall deſire. And by a way I ſhall ſhortly ſhew, the objects may be perceived diſtinct, defined, and colourleſs, as if ſeen by the naked eye. In all theſe ways the manner of applying the light is very ſignificant, and provided it be very ſtrong, the ſmaller the point be it proceedeth from, the more diſtinctly doth it exhibit the difference of refraction in the tranſparent bodies viewed by it, and the plainer will their parts be diſcovered: The light therefore of the Sun either reflected from a Spherical Convex body, or Spherical Concave body, the object being placed beyond the *focus*, or Refracted through a Concave or through a Convex, if the object be placed beyond the *focus*, do exceedingly well. But theſe with the help of a dark Room do yet better, the object being placed in a Table againſt the Light, and all other Light ſcreen'd from the Eye by the Dark Room. Much the ſame thing is done by the Light of a Lamp or Candle in the Night, which is indeed the moſt convenient Light, where Colour is not ſo much looked after.

Whileſt this Diſcourſe was Printing I caſually met with a Treatiſe of *P. Cherubine*, Printed at *Paris*, 1677. Entituled, *LA VISION PERFAITE, ou les concours des deux axes de la Viſion en un ſeul point de l' object*; Wherein the Author pretends amongſt other things to have promoted Microſcopes extreamly by ſo joyning two together, as through them to ſee the ſame object diſtinct with both the Eyes at once, and to ſee a large object all at one view, by which he affirms to have diſcovered ſome miſtakes and untruths in ſome of thoſe figures I have formerly publiſhed in my Micrography. But if he had pleaſed to have read

the Deſcription as well as looked on the Figure, he might have been better informed than by his Preface he would ſeem to be. I deny not but that there are many failures in ſome of thoſe draughts, ſome of my own and ſome of the gravers committing. *Humanum eſt.* But thoſe which he charges for ſuch are not, as he might have ſeen if he had made uſe of better glaſſes than thoſe which he deſcribes, for they are ſo far ſhort of equalling thoſe I uſe, that I can demonſtrate from his own Deſcription of them, that thoſe I made uſe of did magnifie 10000 times more than that with which he pretends to have made theſe great Diſcoveries. Nor is it any thing more than common to ſee as large an *Area* as he mentions, with a glaſs that magnifies no more than his doth. But I could have ſhewed him how he might ſee the whole Creature at once, and yet much more magnifie than that which I have deſcribed, nay though the Creature were twice as big, and that with one Eye only, which is much to be preferred before that with two. However I ſhould be very glad to hear what Diſcoveries he doth make with his binocular Microſcope more than was ſeen before. As alſo that he would pleaſe to demonſtrate the truth of Parallelogram preſcribed for certain uſes, pag. of Dioptrique Oculaire, and in the Fourth Chapter of the Fourth Part of this Book. But to digreſs no farther from what I was deſcribing. I muſt add that with both theſe kinds of Microſcopes have I examined ſeveral ſubſtances; as particularly the ſteepings of ſeveral grains and ſeeds in rain-water. And though I have not yet found any one tincture more prolific than this of Pepper; yet 'tis not the only tincture in which they do both breed and increaſe. I have ſeen ſeveral ſorts in the ſteeping of Wheat, Barly, Oats, Coffee, Anniſeeds, Peaſe, *&c.* ſome not above a third part of a hair in thickneſs; others not above the twentieth part of the breadth of a hair, and ſome not more than a thirtieth part of that breadth; ſo that no leſs than 900 of theſe leaſt muſt go to make an

area

area as big as that of an hair cut tranſverſly, and 27000 to make a Cylinder as big as the hair of ones head, and of equal height with the Diameter of that hair, which one may juſt call a viſible point, and no more; few eyes ſeeing things diſtinctly much ſmaller: Now the Diameter of a hair of my head being by examination found but the 640 part of an inch, it follows that no leſs than 19200 or to uſe a round ſumm about 20000 of them may lie in the length of an inch, and conſequently, that a circle an inch Diameter will be to the *area* of one of theſe cut tranſverſly as 400000000 to 1. four hundred millions to 1 and a Cylinder one inch Diameter, and one inch high, will be to one of theſe mites, as 8000000000000 to one, eight millions of millions to one. If therefore we compare the magnitude of one of theſe animals to the magnitude of other creatures living in the water, we ſhall find that theſe will be found much ſmaller in compariſon to the body of an ordinary Whale, than the body of the ſame Whale will be to the body of the whole Earth; which may prove an argument for an *anima mundi* perhaps to ſome. But let every one make his own inferences, and believe his own eyes, for they will make the beſt impreſſion on his reaſon and belief. Now if the Creature be ſo exceeding ſmall, what muſt we think of the Muſcles, Joynts, Bones, Shells, *&c.* certain it is, that the Mechaniſm by which Nature performs the muſcular motion is exceedingly ſmall and curious, and to the performance of every muſcular motion in greater Animals at leaſt, there are not fewer diſtinct parts concerned than many millions of millions, and theſe viſible, as I ſhall hereafter ſhew through a Microſcope; and thoſe that conceive in the body of a muſcle, little more curioſity of mechaniſm than in a rope of the ſame bigneſs, have a very rude and falſe notion of it; and no wonder if they have recourſe to Spirits to make out the Phænomena: but of this hereafter more.

Further, I have examined the conſtitution of Blood, Milk,

Milk, Flegm, *&c.* and found them much the ſame with what Mr. *Leeuwenhoek* has declared. A little fat laid upon the glaſs plate whilſt warm, melts, and becomes tranſparent, but obſerved in a convenient poſture againſt the light of a candle, *&c.* till it congeals, and ſhrinks, make a pleaſant fluid, and ſhews how conſiderably a fluid and ſolid body do vary, and may give us a good hint to conjecture at the reaſon of the ſwelling and greater lightneſs of Ice than of Water. The firſt beginnings alſo of the ſhooting or cryſtalliſing of Sugar into rectangular parallelipipeds, Alum, Salt, Vitriol, *&c.* are ſtrangely ſurprizing and inſtructive, I could enumerate multitudes of theſe.

But (that I may not detain the Reader too long in the peruſal of theſe anatomical deſcriptions of the minute and inviſible parts of animal ſubſtances) to eaſe both his eyes and imagination I ſhall proceed to acquaint him with ſome Anatomical Obſervations more ſenſible, and which do ſeem more nearly to concern us. And thoſe are contained in the enſuing Diſcourſe, being

A Relation communicated to me in a Letter by that ingenious and experienced Chirurgion Mr. James Young *of* Plimouth, *in the beginning of* January *laſt, of the fatal Symptoms cauſed by a Bullet ſwallowed into the Lungs.*

SIR, In the beginning of *April*, 1674. one Mr. *Anthony Williamſon* of *Liſcard* in *Cornwal*, aged about 65 years, of a brisk, firm habit, became (after a too liberal drinking of Cyder) afflicted with the Colick, of which in four days he cured himſelf, by ſwallowing two Musket Bullets, and receiving ſome Carminative Clyſters. On the 12. of the ſame month, his pain returning ſomewhat ſmarter than before, he attempted to ſwallow three Piſtol Shot, and ſuppoſing it the eaſieſt way, he lay on his back, and threw them all at once into his throat; where they choaking, had almoſt ſtrangled him; conſtraining him to vomit, *&c.* When they were paſt down, he became ſeized immediately with a violent Cough, Wheaſing, pain in the left ſide of his Breaſt, a great noiſe in reſpiration, more eſpecially after a fit of Coughing. for then his Breaſt would hiſs, like the ſucking of a Pump, when the Air deſcends through the boxes.

Theſe accidents ſo ſuddenly occurring, without any manifeſt cauſe, did much ſurprize him, and the more, becauſe he was naturally of a ſound breaſt; the Colick was cured by Clyſters, Potions of Manna, *ol. amyg. d. &c.* and two of the Shot were ſoon ejected, *ex ano*, and maugre the other accidents, he became indifferently well, and able to walk about houſe.

Five or ſix weeks after this, thoſe ſymptoms became more fierce, depaupering his ſpirits, proſtrating his appetite, diſquieting his ſleep with dreams, a *Dyſpnœa*, and rutling violent Cough; a ſtraitneſs and load in his Breaſt kept him in bed, extenuated his body (which without help of Milk Clyſters, was coſtive) he frequently fainted with ſweats, and a tickling ſleepineſs in both legs.

Under the tyranny of this legion of ſymptoms, our Weſtern *Apollo*, Dr. *Bidgood* of *Exeter* was conſulted, who affirmed them all to be cauſed by the remaining Bullet, which paſſing through the *Larynx*, was fallen into one of the branches of the *Trachea*, where it would abide, in deſpight of any endeavours to eject it: yet to alleviate the violence of the accidents, he directed to the uſe of emollient *Eclegma's*, temperate Cordials, *&c.* by help of which, and ſome other propitious circumſtances, he not only recovered his legs, becoming able to walk, and ride a ſmall Journey, but alſo conſummated Marriage with a young woman of 25--- who afterward brought him two Children, whereof one is now alive, and very luſty; and was ſeven months gone with a third, when he died: the more wonderful if the woman were juſt to him (of which there appeareth no reaſon to doubt) becauſe a very little motion would ſo increaſe his difficulty of breathing, as to make him faint.

After Matrimony he had divers lucid Intervals, at times would be very briſk, and at others very languid, and faint, like a dying man: he continually expectorated, ſometimes grumous coagulated Blood, otherwhiles very recent; now purulent fœtid matter, then laudable *pus*. His natural averſion to Medicine cauſed him to reject what was adviſed by Dr. *Bidgood*, Dr. *Lower*, Dr. *Sprage*, *&c.* ſaving a few of the more ſlight mixtures: And although Sack had been formerly very familiar to him, he was now forced to ſhun it, and all ſtrong Drinks, becauſe they would infallibly produce a *Cardialgia*, a pulſant throbbing of the Heart, and labouring in his Breaſt: the firſt of theſe perhaps proceeded from his Conſtitution, which inclined to Choler; but the latter undoubtedly, from the effervescency, and warm motion, to which it enforced the Blood, which the obſtruction and preſſure the Bullet occaſioned in the *Pneumatick* organs, could not peaceably admit of: wherefore he reſolutely fixed to ſmall Drink, and ſhunned, as much as poſſible, all evitable Exerciſe, ſaving that of his

his hands, which he frequently employed in making Net-work.

In the Year 1676. he applied himſelf to our ingenious and learned Country-man, Dr *Mayow* of *Bath*, who agreed with Dr. *Bidgood*, that the remaining Bullet lodging in the Lungs, was the occaſion of all thoſe ill ſymptomes under which he laboured; but ſeemed to diſſent from his preſage, by hoping he might expectorate it: to atchieve which, he directed to have the body ſuſpended head downwards, and fumes of Storax, Benjamin, *&c.* to induce expulſive Coughing, together with concuſſions of the body, and all preceded with an opening courſe, to relax, and dilate the veſſels of the Breaſt; all which were uſed to no purpoſe, ſave to verifie Dr. *Bidgoods* Prognoſtick, that no efflation, how violent ſoever, would be able to extrude it, and inhaunce the Patients deſpair of being ever cured; from which time he never attempted it: ſo that thoſe ſymptomes before mentioned, continuing until the Winter, and then gaining conſiderably on him, eſpecially the *Hæmoptyſis*, *&c.* he languiſhed till the ninth of *December* laſt, and then died.

The tenth *Ditto* (aſſiſted by his Son-in-law) I opened the *Thorax*, in preſence of two other Chirurgions of the place, together with divers perſons of Quality, whoſe curioſity led them to ſee the examination; becauſe the Bullets being there, was ſo much doubted by many, and diſputed as impoſſible by others. In the diſſection the following particulars were obſervable,

The Body was extenuate and tabid,

The right lobes of the Lungs were replete, ſound, and well coloured.

The *Serum* in the *Pericardium* was almoſt all abſumed,

The Heart ſtrangely ſhrivelled and very ſmall.

Under the *Pericardium* (the Body being *ſupine*) we found a lump of coagulated Blood, as big as a Pigeons Egg; near which lay alſo a ſubſtance, ſhaped like an

obtuſe headed muſcle, having a Tendon-like tail, which inſinuated to the Pendant Lobe: Its body was above an half inch thick. Its other dimenſions and ſhape exactly like that of the figure X, of which A ſheweth the head or upper end, B the tail, which in drawing out of the rotten Lungs (being alſo corrupted) broke aſunder. Its Texture ſeemed fibrous, like that of the Kidneys, being white one half way through, the reſt of a dark red: it was very ſoft and plum, having a firm ſmooth tegument, and felt very much like a Sheeps kidney.

The left Lobe of the Lungs was cadaverous, and hollow, by an abſceſs which had diſcharged near a pint of very fœtid and purulent matter, into that ſide of the trunk where it lay immured up, by the adheſion of the Lungs on that ſide, to the *Pleura*, which with the *Diaphragma*, as far as the matter extended, was livid, and eroded.

We examined this rotten part of the Lungs, with what exactneſs and curioſity we were capable of, amidſt ſuch a crowd as were preſent; and the more troubleſome ſtench of the *Cadaver*; and found though the whole *Parenchyma* were rotten, and no firmer than coagulated Blood (with which it had very near reſemblance) yet the branches of the *Trachea* continued into it were uncorrupt, and ſound; nor in any of them could we find what we very confidently preſumed to be there, *viz.* the Bullet.

Wherefore I reſolved to ſeek it the way by which it muſt have entred; and accordingly dividing the *Trachea* at its inſertion to the Lungs, I thruſt in a bended Probe to the left branch, and there felt him, lying looſe about two inches within it, which with my fingers I eaſily expreſſed at the divided end of the pipe: to do which, I laid it bare ſo far as where the Bullet had lodged; and I proteſt, to my wonder, I found it not any way injured, or altered, by hardneſs, eroſion, *&c.* though the Bullet had divers impreſſions from the later.

The

The ſanguiferous veſſels, though lacerated, and cut in the diſſection, did yield little or no Blood, either fluid or coagulate.

Thus far is true Hiſtory, and matter of fact; I muſt now beg your pardon, if I preſume to give my ſenſe, and apprehenſion of ſome of thoſe Phænomena here related.

The extenuation of the body, the abſumption of the *ſerum* in the Heart-bag, and the contraction of the Heart, were the effects of the *Tabes*; and that occaſioned by the Bullets injuring the Lungs, and pectoral veſſels.

The lump of coagulate blood found under the Heart-bag was extravaſate from the rotted veins, and arteries of the Lungs.

That ſtrange ſubſtance lodged between the *Pericardium*, and the Bullet, was either a *Polypus*, and the excreſcence of ſome part, or it was generated by nature, and ſubſtituted for a cuſhion to defend the Heart from injury, by ſo uneaſie a neighbour. That Polypuſes have been found in the Heart, is affirmed by *Nicolas Tulpius*, *Marcellus Malpighius*, *G. Garnarus*, &c. but their ſhape and texture differing vaſtly from that of ours, giveth reaſon to believe this to be none; eſpecially conſidering that they all excreſcing from the Heart, or ſome carneous part, are inſeparably united and radicated to their original, and are ſpungy; whereas this was nothing leſs, having no root, nor ſo much as an adheſion any where, ſaving at the tail; the ſmall end of which, being rotted by the Lungs, into which it continued, did eaſily divide upon my endeavour to draw it out: the body of it alſo lay looſe in the aforeſaid interſtice, and as eaſily ſlipped out, as a Wen, or a *Struma*, when the containing parts are opened. Its ſubſtance was not fungous, but of a ſoft firmneſs, like a Kidney; and in what ever circumſtances it may reſemble a Polypus, as it doth the figure of that of the Noſe, *vide N. Tulpii ob. med. lib.* 1. *obſ.* 26. yet it alſo differs from all other excreſ-

creſcences, beſides, in what hath been mentioned, in that it was not rooted in any fleſhy, bony, or muſculous part; and ſuch the Lungs are well known not to be: it muſt therefore be the ſtupendious effect of Natures induſtry, and laid as a cuſhion to defend the Heart, *&c.* Its compoſition being ſo delicately ſoft, and yet firm enough for ſuch a purpoſe: Its magnitude, ſituation, *&c.* concurring alſo to confirm this opinion concerning it; beſides which, I do almoſt remember, and believe (though I cannot be poſitive) that the pulſant pain he had ſo violently in his Breaſt, toward the left ſide, decreaſed *gradatim*, from the time of the deglutition: if that be true, whatever the ſubſtance were, or its cauſe, its effects were very propitious, manifeſting nature to be, not only a diligent ſupplier of her own defects, but as induſtrious to produce ſtrange and unaccountable relief, in ſuch emergencies as this before us: A reſembling ſtory we have from *A Pareus, lib. 8. cap. 15.*

The abſceſs was without doubt from a Phlegmon of the Lungs; and becauſe for the moſt part it was below, or beyond the Bullet, it proceeded rather from its obſtructing, and ſo ſtagnating the Blood, and recrements in that Lobe, than from extravaſation. What occurred of the latter, was expectorated, or remained in ſuch Coagulums as that found under the Heart.

The cauſe of the Bullets falling, rather into the left than the right *Ramus* of the *Trachea*, is obvious from the more ſupine and direct figure thereof, correſponding with the trunk, as the figure doth manifeſt: which conſideration, together with the Bullets being looſe in the pipe, renders the unſucceſsfulneſs of Dr. *Mayow's* attempt very wonderful: I am inclined to believe it was ſo, either for want of a more early trial, or a more skilful tryer, than him who was employed about it. The way was ingeniouſly contrived, and (as the Doctor himſelf told me) had been ſucceſsfully experienced in the like occaſion. Certainly, had not the diſtance of the Doctors abode, and very important avocations,

tions, denied his perſonal aſſiſtance: or had any other perſon skilled in Anatomy, *&c.* been ſubſtituted, the Bullet from his own favourable ſhape, and more propitious gravity, and particularly from the ſtrong efflations they provoked, together with the aſſiſtant poſture of the body, would have been extruded. Had they inſtead of hanging him perpendicular, made him incline a little to the right ſide, to have made the left *Ramus* more prone; and at the ſame time made him diſtend the pipes by ſucking in as much breath as they could contain, their other means might have been effectual; which I am induced to preſume from the proſperous effects of the like attempt, and yet wanting many of their advantages; I mean the reverſion of a Stone, when ſticking, and not able, to paſs through the Urinary Channels. Let any Phyſicians ſeriouſly perpend the difficulty of this, with the advantages for the former, and they will juſtifie my opinion.

The eroſion of the *Pleura*, and *Diaphragme*, was from the acidity of the matter, gnawing and corrupting them; for though the *Trachea* wonderfully eſcaped ſuch impreſſions, the Bullet diſcovered on its ſuperficies, divers marks of eroſion, which all acids produce with much facility, upon the ſaccharous or ſaline parts of Lead; as is to be ſeen by immerſing it in vinegar.

And now Sir, to relieve your patience (no leſs than my own) perhaps already wearied with the prolixity of this Narrative, give me leave to conclude, with ſuggeſting, that I am of a belief (having peruſed moſt of the publick accounts of this kind) that ſcarcely a rarer accident, and accompanied with ſuch ſtupendious circumſtances, hath occurred to the preſent age than this; that an extraneous body, ſo large, ſo heavy, ſo hard, ſhould ſlip down that difficult, and unuſual way of the Weaſon, and abide ſo long in the organs of reſpiration, in ſo aged a perſon, admitting after it ſuch exerciſes, as he performed, Riding, Marriage, *&c.* that nature ſhould ſo unaccountably provide ſuch a pertinent

fence

fence againſt injuries accidentally accruing, and that even the ſmalleſt Ramifications of the *Trachea*, though immerſed in ſuch a *Cadaver*, ſhould be preſerved from injury thereby. I am ſure in the voluminous Obſervations of *Schenckius*, *Horſtius*, *Riverius*, *Bartholine*, *Burnet*, &c. nor among all the ſtories in Mr. *Oldenburg*'s Tranſactions, or the *Miſcellanea Curioſa* of the *Leipſwick* Doctors, hath it a Parallel.

This, and whatever is elſe contained in this Hiſtory, as my *Sicke*, I ſubmit to the better ſenſe, and reaſon of the Learned, not preſuming to be poſitive in any thing, ſave in affirming my ſelf, *&c.*

JAMES YOUNG.

P. S.

For the plainer underſtanding where the Bullet lodged in the Wind-pipe, I have drawn and ſent you an exact figure of the *Trachea*, excarnified; as its to be be found in *Gerrard Blaſſius*, *Syntagma Anatomicum J. Veſlingi.* See figure Y in the III. Table.

C points to the *Trachea* divided under the Larynx.

D the right Ramus of the *Trachea*. *E* the left.

F the place where the Lungs adhered to the *Pleura*.

g g g, *&c.* the extremities of thoſe branches of the *Aſpera arteria*, divaricated into the rotten Lobe.

H the Bullet in the pipe where it was found.

ERRATA.

PAge 1. line 17. *foot.* p. 2. l. 6. *joyned*, p. 8. l. 21. *Cete*, p. 11. l. 5. *is diffuſed*, p. 11. l. 17. *Foſtor*, p. 12. l. 33. *within the ſphere of its activity*, p. 12. l. 34. dele *as*, p. 14. l. 8. *ether*, p. 19. l. 7. *common ſights*, p. 22. l. 31. *Auzout*, p. 23. l. 19. *been produced*, p. 24. l. 27. add *ſee fig.* 4. p. 27. l. 5. *of this orb*, p. 27. l. 21. m, p. 28. l. 27. *ſixth figure*, p. 29. l. 18. *& perige*, p. 29 l. 25. *B, B, E.* ib. l. 26, 27. *H, H, I* p. 31. l. 9. *for* (.) put (,) p. 32. l. 28. *ſtream of bubbles*, p. 35. l. 29. add *fig.* 9. p. 38. l. 28. *to get out of*, l. 34. *of finding the*, p. 46. l. 31. *Baldwines* p. 49. l. 17. *downwards ſhall touch*, p. 54. l. 26. *Scolopendra*, p. 69 l. ult. *Suns phaſe*, p. 71. l. 25. for 43 put 34, p. 83. l. 8. *to my wonder*, p. 93. l. 3. blot out *firſt*, p. 96. l. 14. *plano connexes*, p. 101. l. 22. for *table* put *tube*, p. 101. l. 30. *Seul*, p. 102. l. 17. *magnified*, l. 23. *the paralellogram*, l. 24. *page* 241, p. 104. l. 6. for *fluid* put *feild*.

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Tab: III.ª

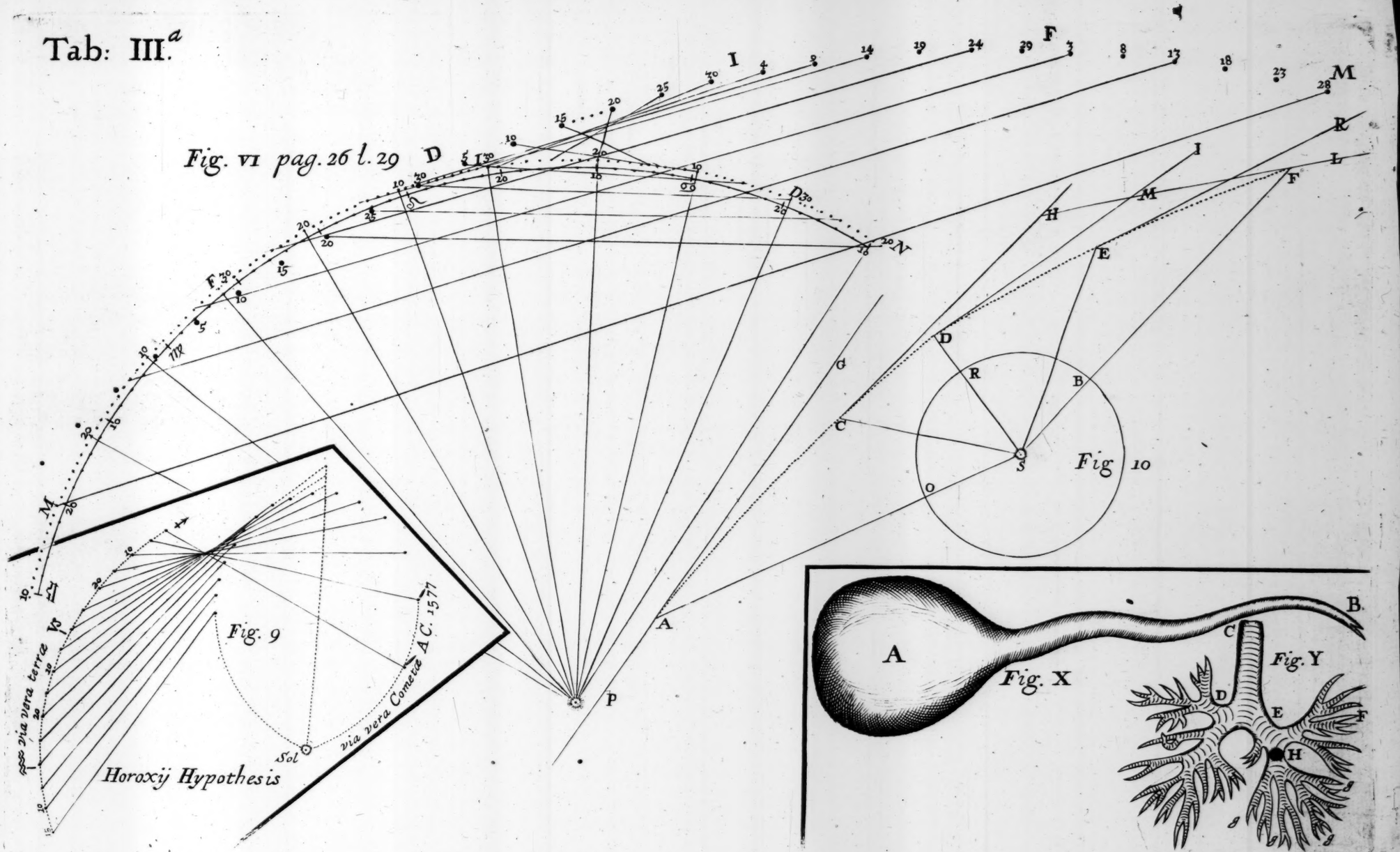
Fig. VI pag. 26 l. 29
Fig. 9
Horoxij Hypothesis
via vera terræ
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Fig 10
Fig. X
Fig. Y

Tab: IIII.[a]

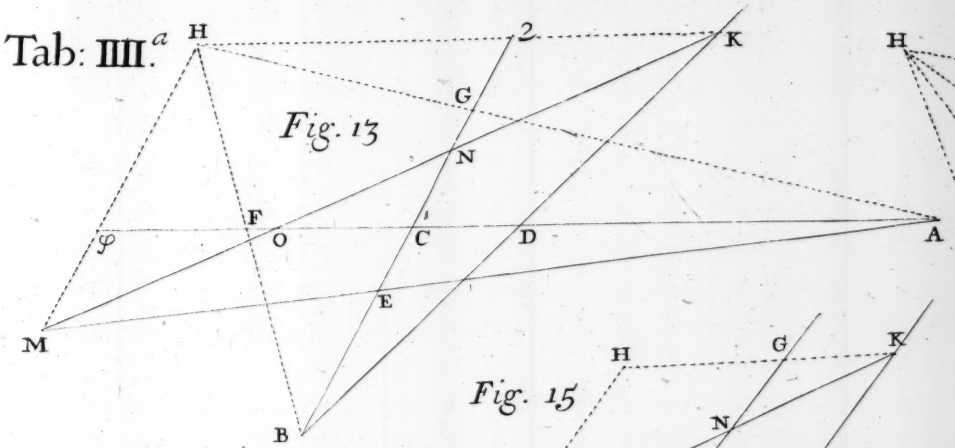

Fig. 13

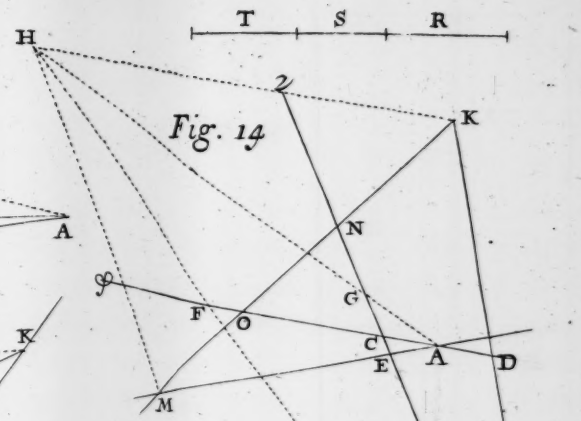

Fig. 14

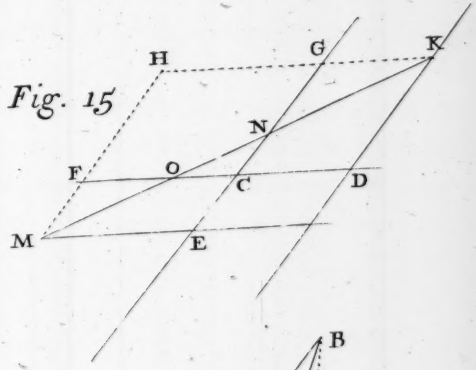

Fig. 15

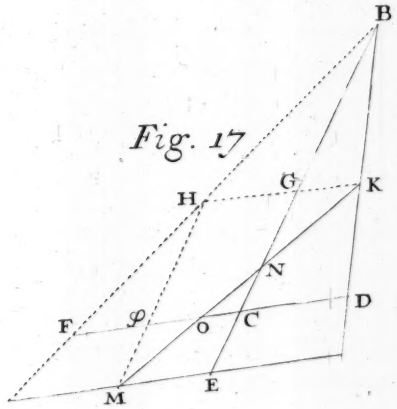

Fig. 17

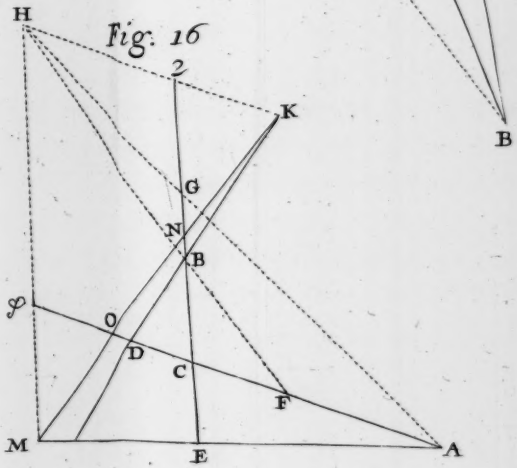

Fig. 16

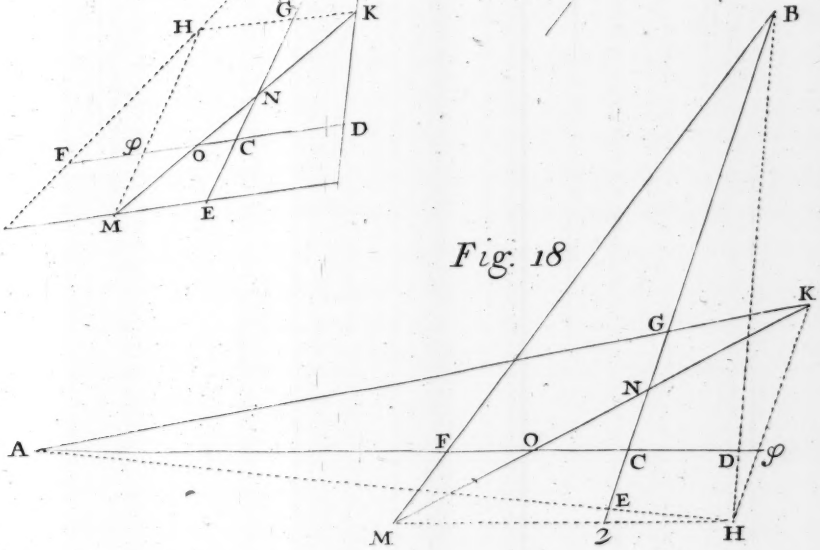

Fig. 18

Tab. V.a Hypothesis Di. Chri. Wren. Equ.

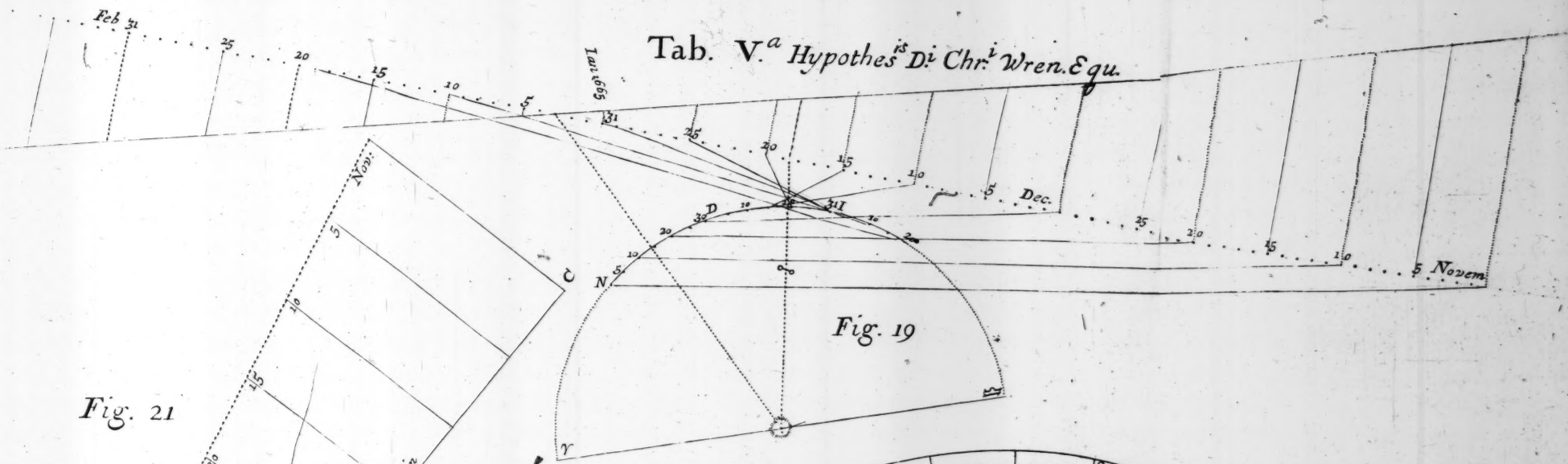

Fig. 19

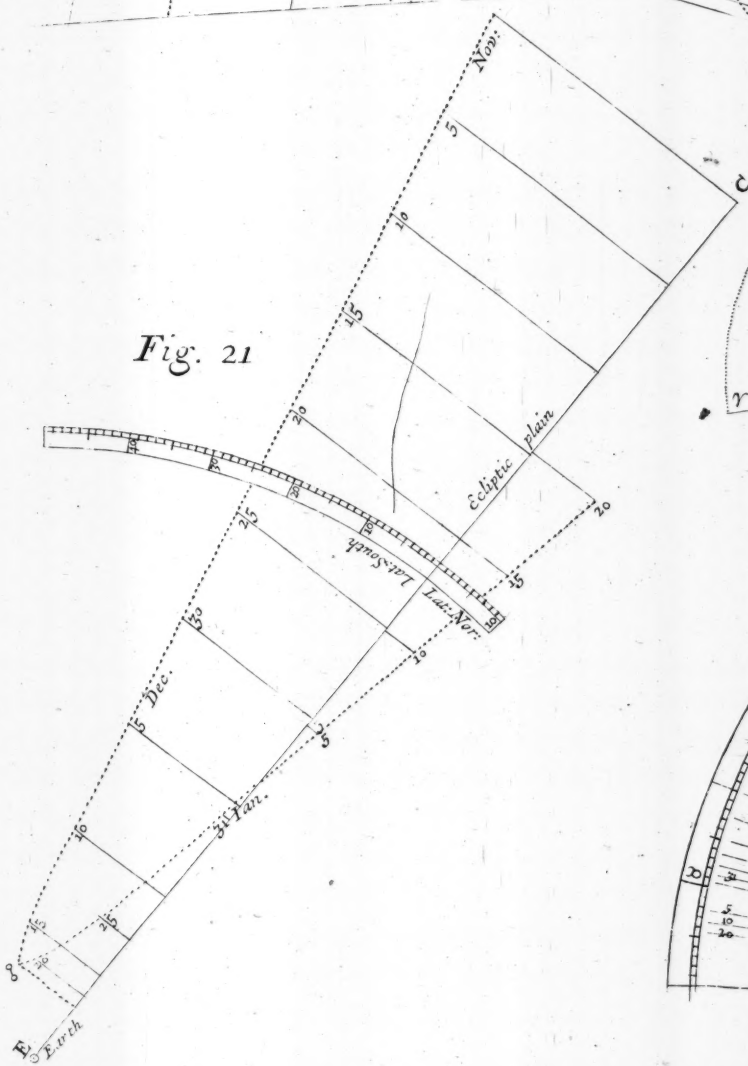

Fig. 21

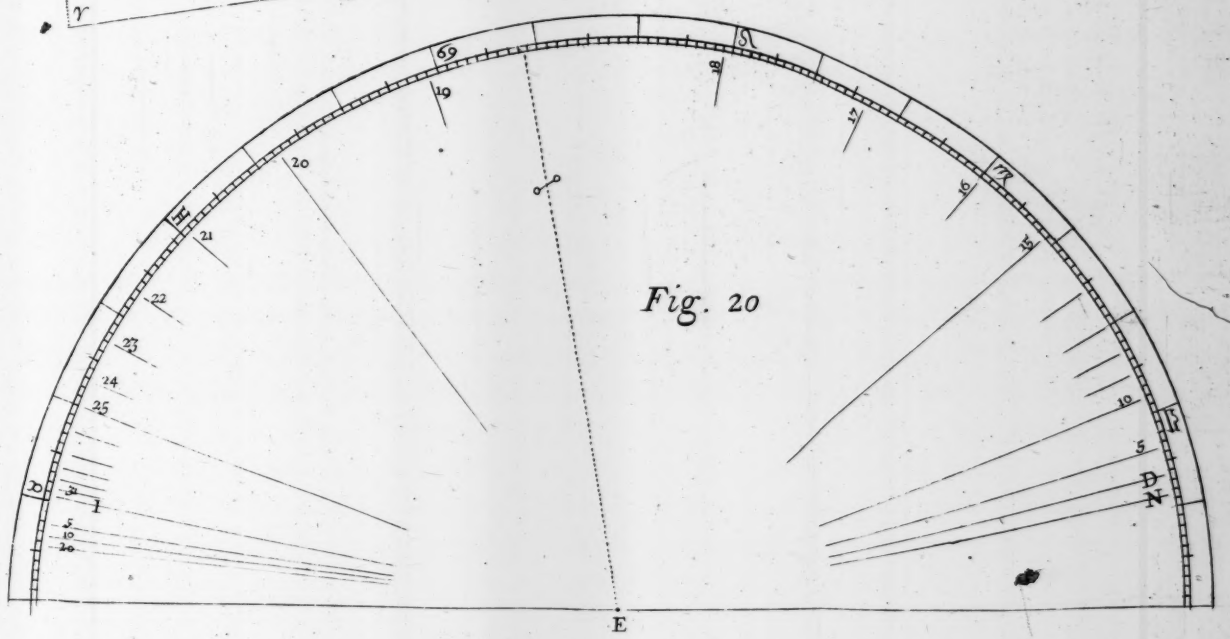

Fig. 20